

AMD RYZEN 5 2400G
Budget gaming gets a
new lease of life **PG. 78**



RETURN OF A LEGEND
Cooler Master's new
Cosmos unboxed **PG. 44**



SECURE YOUR CRYPTO
Use an Electrum wallet
to protect your cash **PG. 64**

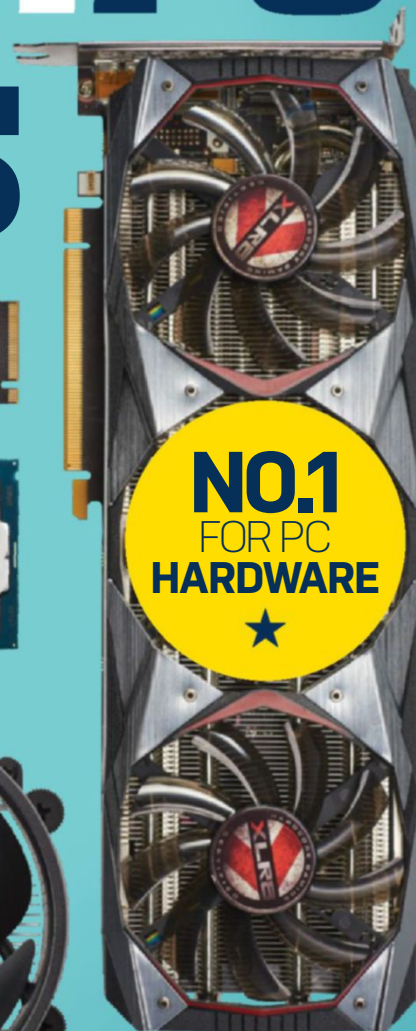


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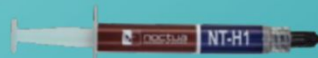
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APRIL 2018

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26 BUILDER'S BIBLE
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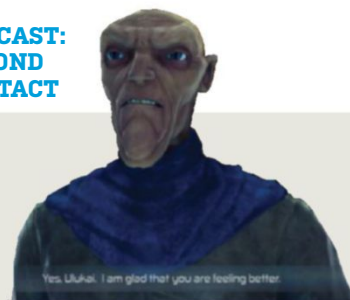


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HD 7.1



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Cyberpower Aura Gaming Headset

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Asetek Liquid Cooling System



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NVIDIA® GeForce® GTX 1070 Ti 8GB Video Card

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Optional



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A portrait of Angie Foss, a woman with long, wavy brown hair, smiling. She is wearing a dark top and a necklace with a circular pendant. The background is a light gray with white diagonal lines forming a large 'X' shape. A purple diamond shape is overlaid on the right side of the image, containing the text 'LEARN FROM THE BEST'.

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Angie Foss
Associate Dean
of Operations
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Tuan
Nguyen

THE BUILDER'S CURSE

I THINK I'M CURSED. For the life of me, I can never seem to build a PC that works the first time around. You might be thinking, "How's that even possible?" But the truth is, it's happened every time I've built a machine, whether it's for myself or someone else. Things always go wrong. Even when I'm upgrading, things go wrong. Once I bought a blazingly fast 52x CD-ROM drive to upgrade my aging unit. It didn't work. I had to exchange it for another. It's so bad that my uncle once asked me to help him build a PC, but instructed me not to touch anything, only sit there and tell him where to put things. Like I said: cursed.

To make sure you won't have the same horrific building experiences that I've had, we're going to walk you through all the tips and tricks to not only build an amazing rig, but to do so while avoiding the common mistakes and problems.

There are lots of little details that get overlooked, especially as you become more confident about the whole building experience. For instance, BIOS updates. Motherboards—even a brand new one you've just received—tend to ship with old BIOS revisions. The first thing you should do once your PC is booted is update your motherboard's BIOS. I always prepare a little USB stick with the most recent revision.

Another invaluable tool to have is the magnetic screwdriver. I can't count how many times I've dropped a case screw down into the bowels of my nearly finished PC. But you know what's the worst part of all? When the damn screw falls down between two PCIe cards. If you don't have a magnetic screwdriver,

you can buy a magnetic extendable wand for cheap. You'll thank me later.

I tend to build my PCs on the floor, because it gives me more room to work, but if you build your PC on a table, there will come a time when a screw will just run away from you. To prevent this, get yourself a magnetic screw mat or bowl. I prefer a mat to a bowl because I can lay out the screws in the same fashion as they are on the device I'm taking apart. Letting a screw fall down into your case somewhere is frustrating enough; losing it completely is even more aggravating.

One last pro tip: Read the manual! I can't stress this enough. Admittedly, I'm one of those people who tend to skip the manual and jump right into the action. This is a mistake. My most recent lesson? Installing an Intel Optane M.2 drive into one of my mobo's M.2 slots. I noticed that when I had the Optane installed, one of my SATA hard drives would fail to be detected by the BIOS. Of course, I had already set up everything and closed my case before realizing—by reading the manual afterward—that installing a drive into that particular M.2 slot disables one set of SATA ports, due to PCIe lanes.

No matter how experienced one gets, one will always make mistakes, but we're here to help.

Tuan Nguyen is Maximum PC's editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 20 years.

submit your questions to: comments@maximumpc.com

THE NEWS

New Chips, New Problems

Low-power Raven Ridge, more Coffee Lake, lots of lawsuits

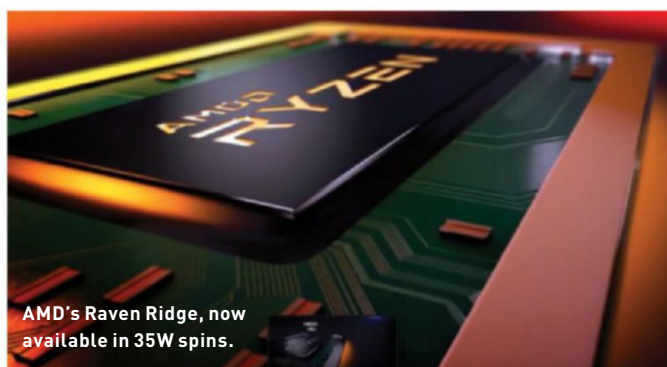
EVEN WITHOUT a major launch, it's never quiet with Intel and AMD, both of which are busy consolidating their ranges and trying to shake off the fallout from Spectre and Meltdown, which won't be easy or cheap.

Having launched a full range of new architectures last year, AMD is fleshing out the range and filling in the gaps. Imminent are two low-power versions of its rather tasty Raven Ridge APUs: the Ryzen 3 2200GE and Ryzen 5 2400GE. Power consumption drops from 65W TDP to a svelte 35W. They share the same basic specifications as their big brothers; the cost for the parsimonious power use is clock cycles. The 2200GE drops the base clock to 3.2GHz from the 2200G's 3.5GHz, while the 2400GE loses 400MHz over its big brother. It's not clear yet what the boost clock rates are, but expect a drop there, too. We take a closer look at the Ryzen 5 2400G on page 78.

Raven Ridge has attracted praise—at last we have on-board graphics with some punch. However, there is a small

problem with compatibility. Few AM4 motherboards currently support them without a BIOS update, which can be a problem if you don't have another chip to boot it in the first place. AMD can lend you a boot kit to get you going, though—essentially an A6-9500 APU and cooler to get your rig running for the update, then you send the chip back. It's available via AMD's online warranty claims page.

Meanwhile, over at Intel, we have had yet another one of those "leaks," where a partner accidentally (or not so accidentally in some cases) lets slip what's just around the corner. Once again, online retailers have started listing chips that aren't officially launched yet. In this case, we are due three new Coffee Lake chips, the first since the initial launch. We get the Core i5-8600, i5-8500, and i3-8300, all with locked multipliers. The six-core i5-8600 hums along at 3.6GHz with a 4.6GHz boost, all for \$208. The i5-8500 looks to be a slightly slower version of the same at \$189. The i3-8300



quad-core runs at 3.5GHz and comes in at \$135.

These new Intel family members fill some performance gaps and are aimed at more budget-oriented systems, using the new H370 and B360 boards, which are also coming soon. The Core i5-8500 looks like good value, as it's faster than the similarly priced i5-8400.

We've been waiting for Intel to announce something graphics-related since it hired ex-Radeon chief architect Raja Koduri. It has, and it's an unexciting research prototype for proof of concept of voltage control and power management. Still, it's only been three months since Raja joined; the phrase "Intel Graphics" hasn't caused a stir for years, and it has nothing to meet Raven Ridge head-on. Something is brewing, though.

Both AMD and Intel are still knee-deep in the Spectre and

Meltdown bugs. Now the legal profession has waded in (who didn't see that coming?). Class action lawsuits have been filed. AMD currently has four, and Intel has managed to attract 35 cases, although by the time you read this, it'll probably be more. They are being brought by customers and investors alike, and cite misrepresentation, non-disclosure, and selling faulty goods. They will defend themselves, as big companies do, but it looks as though there will be large bills at the end of it, either way.

It's not clear whether we've seen the last of the Spectre and Meltdown patches, either; Intel has just released a new version, presumably one that won't cause some systems to go bananas. It isn't alone—Microsoft's initial patch was pretty shaky, too. And that's a quiet month.... **-CL**



Online retailers have started listing Intel chips that aren't officially launched yet.

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INDUSTRY WANTS TO KILL OLD ONLINE GAMES

Move to preserve classics faces opposition

IN DECEMBER, the Copyright Office started considering whether to allow museums—specifically the Museum of Art and Digital Entertainment—to run old online games, such as *EverQuest* and *City of Heroes*, to preserve them. Researchers are already allowed to circumnavigate security on old games, but the museum wants to go one further, and run fully playable servers that visitors can use. Sounds reasonable enough—games are part of our history, and once the commercial servers are shut down, they shouldn't be allowed to die completely.

The Entertainment Software Association has moved to block the proposal, however, issuing a 40-page list of arguments against it. It cites the fact that since the museum charges for entry, it is making commercial use of the games, a clear copyright breach. It also does not relish the prospect of having source code delved into, a job that the museum would outsource to "affiliate archivists." It has raised concerns that the DRM-free versions would escape into the wild, and tap into the retro game market that it is trying to mine at the moment. It doesn't want to compete with its own back catalog.

The game makers are in something of a quandary here. They want people to get attached to games, to invest time and effort building characters, and identify with the world they have created. Then it would also really like it if you abandon all you've worked for, and start afresh with its latest offering. In the end, games deserve to be preserved, and to block them would mean losing a big slice of gaming history. Back in 2003, a ruling allowed non-online games to be preserved, enabling children to gaze in wonder at the blocky world of the original *Doom*. A ruling is expected by October. **—CL**

DIRECT PURCHASE COMES TO MIXER

WATCH IT, LIKE IT, BUY IT

MICROSOFT IS ADDING the ability to purchase its games directly through Mixer. Streamers can elect to promote downloadable content from the Microsoft Store on their feeds; a link next to the channel name will activate a pop-up window to the promoted DLC. When you buy anything, it is added to your Xbox or Windows library—no need to stop watching or redeem codes. In return, the channel owner gets a 5 percent slice of any sale. Initially, the option will only be available to Mixer Partners, but is expected to be available to all in due course.

Twitch added a similar system last year. The ability for streamers to make money is important to attract and keep the top players, as YouTube Gaming, Twitch, and Mixer fight for market share. Each competes to hand out the best candies to popular gamers through free gaming stuff, virtual tips, and real money. See, Mom? Playing games is a job. **—CL**



VENEZUELA LAUNCHES CRYPTOCURRENCY

Government-backed and based on oil

DESPITE HAVING the world's largest oil reserves, Venezuela is in a financial mess. To help earn hard currency, the government has launched its own cryptocurrency, the Petro, backed by those oil and mineral reserves. What's more, the government has decreed that government industries use it, and that citizens can use it to pay taxes and buy other services.

It's a slightly odd development, because a keystone of cryptocurrencies is that they are independent of state control, and have no collateral. No longer, it seems. The initial offering went well, if President Nicolas Maduro is to be believed. He claims it raised \$735 million, although it's not clear who the largest investors were. He also plans to launch a second currency, Petro Gold, backed by the state's gold reserves. Iran is also said to be considering a similar state-backed cryptocurrency. One benefit of a cryptocurrency is that it can evade sanctions, something currently hurting both countries. **—CL**



Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

TEENY C64 RETURNS

The trend for retro gaming continues with the half-size and fully-functional Commodore C64 Mini, with 64 games for \$70.

ONE TICK A YEAR

The installation of Jeff Bezos's \$42 million, 500ft tall mechanical clock has started, designed to run autonomously for 10,000 years.

CHARGING BY LASER

Engineers have demonstrated a system that can charge a cell phone via a laser across a room.

TRAGEDIES

FORM OVER FUNCTION

Apple's new HQ apparently has employees walking into the glass dividing walls, distracted by their smartphones. Yes, that's irony.

COINBASE FLAW

A bug caused payments for small transactions to be processed multiple times.

TESLA CLOUD HACKED

Tesla has been a victim of cryptojacking—stealing resources for cryptocurrency mining. No data was stolen, just clock cycles.



Jarred Walton

TECH TALK

The Pros and Cons of Integrated Graphics

A YEAR AFTER THE LAUNCH of AMD's Zen architecture as a CPU-only solution, AMD returns to the APU market with its first Ryzen APUs. Packing more graphics cores than ever, they promise to eliminate the need for dedicated graphics. And they can do that. Sort of. If your graphical needs aren't too high.

The big problem with most integrated graphics solutions is that the CPU and GPU portions of the processor must share limited system memory bandwidth. Even with a dual-channel 64-bit DDR4-3200 interface, that's only 64GB/s. If that sounds like it should be more than sufficient, consider that even Nvidia's budget GTX 1050 delivers almost twice that much, thanks to a 128-bit GDDR5 interface—and all 112GB/s on a GTX 1050 gets devoted to GPU duties. In the computing playground, GPUs are the big, greedy bullies that don't like to share with other children.

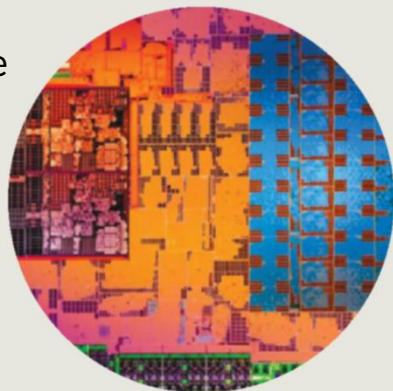
That doesn't make AMD's Ryzen APUs bad—on the contrary, I like what they bring to the table. But as a gaming solution, they're scraping the bottom of the barrel. In benchmarks, the faster Ryzen 5 2400G with Vega 11 graphics sometimes wins, sometimes loses against the ultra-budget GT 1030 and RX 550. Those are \$80 parts, so you're paying \$170 for a CPU and integrated GPU that end up slightly slower than a CPU and dedicated graphics card. But that's only if you opt for high-performance DDR4-3200 memory; go with bog-standard DDR4-2400 or DDR4-2133, and you lose 15-20 percent of the graphics potential, thanks to the bandwidth bottleneck.

AMD's 2200G loses some of the graphics and CPU cores, but gets the price even lower. At \$100 for a CPU and graphics solution that's twice as fast as any of Intel's current crop of integrated graphics, that's

hard to beat. But 1080p gaming will struggle at times—you'll often end up at minimum quality, and sometimes be forced to run at lower resolutions. Mostly thanks to that memory bandwidth bottleneck.

Ironically, Intel is pursuing the higher performance integrated graphics solution, with its upcoming Eighth-Gen Kaby Lake-G parts. They'll use AMD's Radeon Vega graphics, the major difference being the inclusion of twice as many GPU cores and a dedicated stack of HBM2. They will truly eliminate the need for a dedicated graphics card for moderate gaming needs, but the Kaby Lake-G processors will be for laptops and NUCs, not larger desktops. And that's fine, because larger desktops will almost always benefit from the lower pricing that comes from not having to cram as much performance as possible into the smallest space possible.

If there's one area where AMD's APUs really shine, it's HTPC use. Thanks to AMD's graphics experience, both video decode and encode acceleration are present and work well. I tested the chips in MSI's B350I Pro AC motherboard, a compact Mini-ITX form factor, and it worked great for HTPC duties. Even better is that it idles at around 20W of power, and only consumes



Ryzen APUs devote a large chunk of the die to graphics.

about 30W when watching 1080p video streams. Combine this sort of system with a good home NAS that holds all your media, and you're set.

Long-term, it will be interesting to see where AMD and Intel go with integrated graphics. Intel's Iris Pro Graphics tried to boost GPU performance, but drivers and cost were never strong points. Intel's drivers have improved, however, and with additional work, we could see Intel go back to its own GPU solution for high-end integrated graphics. AMD, on the other hand, just needs to reach a point where it's economically feasible to stuff more GPU cores and some dedicated memory (HBM2 or even HBM3) into a package. Eventually, that's bound to be more cost effective than using a CPU with a dedicated GPU—though the performance conscious will always opt for a discrete graphics card.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.



As a gaming solution, AMD's Ryzen APUs are scraping the bottom of the barrel.

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THE LIST

8 VR EXPERIENCES YOU HAVE TO TRY

8



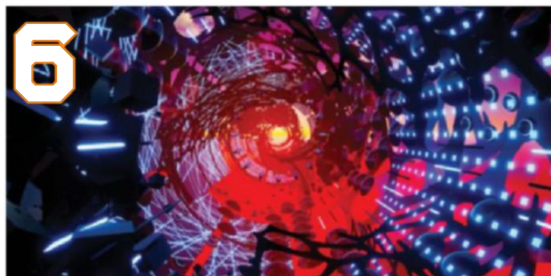
GOOGLE EARTH Go from gigantic towering god to tiny street-level ant with this unique view of the world.

7



KEEP TALKING AND NOBODY EXPLODES You can see the bomb; friends have defusal instructions.

6



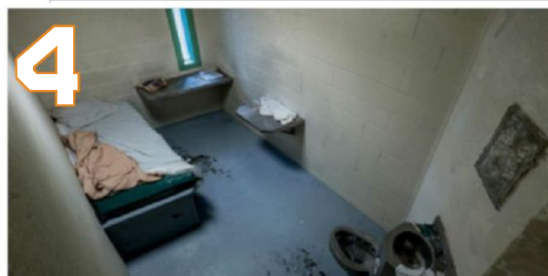
FANTASYNTH A seven-minute acid trip through the craziest music visualizer ever—live version coming soon.

5



GORN Comical violence, buckets of syrupy blood, and ridiculous weaponry in a dumb-fun gladiatorial “sim.”

4



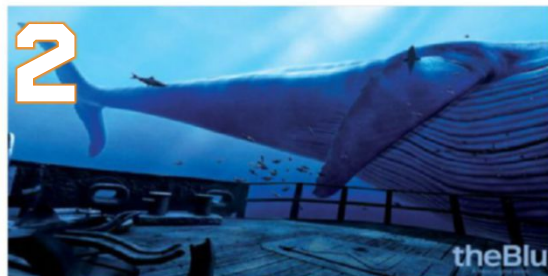
AFTER SOLITARY Step into the cell of former inmate Kenny Moore to experience life behind bars.

3



COCO VR Disney-Pixar’s Oculus-exclusive trip into the afterlife is a cute, touching, fun experience like no other.

2



THEBLU Hurt your GPU with a stunning trip to the bottom of the ocean, where the scale of VR comes to life.

1



TILT BRUSH Wave your arms to sculpt, paint, and create things in 3D—the world is your virtual canvas.



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HEAD TO

BY ALEX COX

Mesh vs Wi-Fi vs Ethernet

A functioning network isn't just a luxury—it's one of life's essentials. Heat, water, and delicious broadband piped through the home. But there's a lot to choose from, both in terms of standards and individually within those brackets. We're not here to pick out specific hardware, but if you're looking to renovate your network, you'll need to make the right choice. Will it be good old Wi-Fi? Perhaps its close cousin, mesh? Or do the reliable wires of Ethernet make the most sense? Read on, and choose what works for you.

ROUND 1	ROUND 2	ROUND 3
Reliability Wi-Fi has come a long way since the days of 802.11b. It used to be the purist's favorite sneering target, both for its sorely lacking speed and the fact that anyone operating a microwave within three miles would essentially render the 2.4GHz band unusable. Microwaves still throw out interference, but 5GHz means that's not quite true anymore. That said, lower-end Wi-Fi does have its issues, particularly when there's a lot of competing signal around. Finding a free channel in a built-up area can be tough, and fighting with metal and concrete structures is still a problem. Electromagnetic fields, too, are a big issue for Wi-Fi signals: If you've ever noticed a dip in signal quality over the holidays, you can probably blame those flashing festive lights. Mesh, given its multiple points of contact, does help to alleviate many of the problems of Wi-Fi reliability. If one node is getting hammered, the second (if it's in range) should be able to back it up—but if you're relying on a wireless backhaul, your problem could simply be made worse. Ethernet? Once it's wired in, it's working—as long as nobody plugs in anything stupid. If stability is your concern, stick to the wires. Winner: Ethernet	Speed Measuring speed in a Wi-Fi context is difficult, as throughput and lag are often dependent on which specific devices are at either end of the argument. Get a MU-MIMO router and a wireless card that supports multiple channels, keep them free of obstructions, and there's no reason you can't achieve throughput way beyond the maximum capacity of your broadband connection. Mesh might not be quite as easy, because there needs to be a backhaul channel managing communication between the nodes. If, like Linksys's Velop, there's no dedicated wireless radio for this purpose, you may find inter-device communication slightly slower in busy periods. Unless, that is, you choose to do your hauling via Ethernet, at which point, the argument turns on a dime. Ethernet, even if your home is strung up with drilled-through last-century Cat 5, should be able to support Gigabit networking. It's faster than even wireless. Maximum throughput depends on the quality of cabling as well as rating, and if you're installing today, you'd be a fool not to string up some 10G-compatible Cat 6, which improves Ethernet's susceptibility to crosstalk, as well as boosting its top speed. Winner: Ethernet	Convenience When you need to get connected, your network had better be there for you. Wherever you are, whatever you're using, you want to be able to get up and online as quickly as possible. While Ethernet has had a good run, this hugely subjective case—because if you're not also running at least a little Wi-Fi alongside your wires, we're a bit confused as to why—is where it falls down. A wireless network, configured properly, is there. It's waiting. Want to hook up a new device? Just sign in. Want to get your friends on board? Let them into your guest network. Portable devices, no problem. And those moments when you're not in range of a convenient Ethernet outlet or cable aren't an issue at all. Mesh, invariably, makes this even better—extending your Wi-Fi network used to be a massive hassle, with multiple SSIDs and, generally, confused devices. However, with a mesh setup, everything's on the same page by default. Ethernet does have some plus points in this area (there are no passwords to deal with, for example), but mesh, which often offsets its management facilities to an ultra-convenient cell phone app, has it utterly licked. Winner: Mesh

HEAD



ROUND 4

Expandability

Device limits in networking are, mostly, pretty theoretical. Your router might say different, but a single Wi-Fi network, in theory, will top out at around 250 connected devices, a limit that even the busiest home is unlikely to reach. In practice, the more devices a Wi-Fi network concurrently manages, the slower the experience will be for everyone. Even modern routers, well-managed in firmware, and toting MU-MIMO radios, can end up sluggish if they're firing off traffic in many multiple directions. Mesh spreads that noise from one radio to multiple nodes throughout your home, and its other benefit is rather obvious: If you want signal where there is no signal, you can just add another node. There's usually a node limit, but not one that would go beyond even the largest mansion.

Ethernet can go a long way—if you need more ports, add another switch—but every new port needs another wire. If you're installing Ethernet in your drywall, it's a darn sight more difficult to bring connectivity to a new room than the same process with a wireless solution, and there's a 328-foot limit to cables, so you'll need a repeater if you want to go further.

Winner:
Mesh

ROUND 5

Price

It's not a technical issue, but price is important when putting the networking techs head to head, particularly because it's mesh networking's big downside. For all the "just grab another node" arguments, that's rarely a cheap solution. In fact, it's often as hard on the wallet as picking up a whole new wireless router, because in a sense, that's what you're doing. If you're in a smaller home, a single standard Wi-Fi router is probably enough, so you can steer clear of more expensive mesh packages anyway, and if you're lucky, your broadband connection comes with a router. It might be shoddy, but you're paying for it anyway. That's a sunk cost.

Ethernet can be cheap, particularly if you're prepared to wire it yourself, but installing it with professional help is far from inexpensive. That said, a good backbone will last you; line up Cat 6 cable, and you're prepared for future speed upgrades either end of the wires, something that isn't true for either of the wireless solutions. With 802.11ax on the horizon—expect early hardware this year, and realistically adoptable gear in mid-2019—a big investment in mesh right now might soon sting if you're trying to stay cutting edge.

Winner:
Wi-Fi

And the Winner Is...

You know us. Speed and reliability are the core of our being. But new tech is equally important, so this isn't a clear win for Ethernet. Wi-Fi's drawbacks don't completely disqualify it either—we've gotten along with it just fine so far, and it's due to get better. Wi-Fi and mesh suffer in terms of latency, but they're good enough for most; it's the latter's leap forward in connectivity and expandability that puts it leagues ahead of its one-node cousin.

So, if we were to presume you come from some alternate reality where you didn't have a network at home, we'd have two choices. The awkwardness of Ethernet is trumped by mesh's flexibility; mesh's expense is beaten by Ethernet's upgradeability. We'll skip over the irony of mesh working best if supported by an Ethernet backhaul, because we have to peg it as our networking pick. It's the easiest way to fill your home with rock-solid wireless networking, it has easy configuration options, and it's only going to improve. Don't throw out your Wi-Fi router if you're not struggling for signal, but consider mesh your next upgrade. 🔌

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

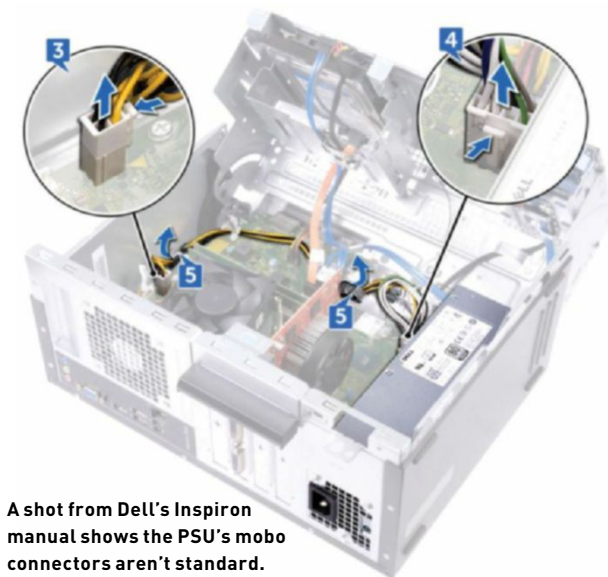
> First-Time Builder > Custom Restore > PSU Standards

Welcome, First-Timer

Doc, After years of upgrading my desktops (starting with a Tandy 1000 EX), I'm at the point where I plan to build my own system. For the past five years, I have been using a laptop to convert my DVD collection into files. Although this works, I know a desktop PC would give me more storage capacity for streaming movies and TV shows. The program I use can either utilize Intel's on-board graphics or an Nvidia card (my laptop, unfortunately, has AMD graphics inside).

I'd prefer not to spend more than \$700, as this won't be a gaming rig. But I would like a respectable processor/graphics card combination that won't be bottlenecked. I intend to use 16GB of RAM, an SSD for Windows and programs, and hard drives for media storage. Of course, I'll also have an optical drive or two in there. Do you have any suggestions for something that would be relatively speedy in the conversion process, but not overshoot my spending goal? **—Richard C**

THE DOCTOR RESPONDS: The Doc got his start with a Tandy 1000 EX as well. While all of his friends were enjoying their



A shot from Dell's Inspiron manual shows the PSU's mobo connectors aren't standard.

first tastes of *Wolfenstein 3D* and *Doom*, he was tooling around with modem cards, mouse boards, and early versions of Windows, almost a decade behind them. But back to your question. If you have no intention of gaming, the expense of a discrete graphics card may not be necessary. You see, the on-die HD Graphics engine built into Intel CPUs is plenty suitable for light 3D lifting. More relevant to your stated purpose, though, Quick Sync Video is beyond competent at transcoding media files. If the software you use is optimized for Intel's hardware, it's probably using Quick Sync

to turn DVDs into more portable files very quickly.

For anyone not in the know, Quick Sync was introduced seven years ago as part of certain Sandy Bridge-based CPUs. It initially supported H.264 encode/decode, but has evolved to incorporate fixed-function acceleration of other formats across Windows, Linux, and macOS, through a great many third-party apps.

With no graphics card on your shopping list, funds are freed for faster components. A six-core Core i5-8600K, low-cost Z370-based motherboard, 16GB DDR4 memory kit, modest-capacity SSD, and

plenty of mechanical storage should allow you to duck in under \$700.

Have It Your Way

Hello, Doctor. I've been an avid reader and subscriber to the magazine since 1998. Keep it going. Now, my question: I have a custom-built desktop running Windows 10 Fall Creators Update. How do I go about building my own custom restore/refresh image? Thank you in advance.

—Orlando Adames

THE DOCTOR RESPONDS:

The January 2018 issue of *Maximum PC* explained how to create a customized recovery disc with AIOME PE Builder 2.0, enabling you to roll portable tools and drivers into a package for recovering or reinstalling Windows.

Or, if you're looking to build install media that includes your favorite applications by default, check out Microsoft's online manual discussing push-button reset under the Windows Recovery Environment (<https://go.gl/BS2dXQI>). It's an OEM-centric process that involves several Microsoft Windows Assessment and Deployment Kit components, plus a separate PC that has at least 100GB of free space.

↘ submit your questions to: doctor@maximumpc.com

Money for Nothing

Hey Doc, I bought a new system last year (in the April timeframe), and some of my components included rebate offers. I sent these in, following their instructions to the letter. More than eight months later, I received notices from MSI and Asus that \$20 pre-paid Mastercard debit cards were just sent out.

Is this a reasonable amount of time to wait? Are rebates just a scam that component vendors use to hold on to our money? I also have one I sent to Seagate around the same time, but have not heard anything back.

—Colm G

THE DOCTOR RESPONDS: Thirty-two weeks? That's well beyond a reasonable wait, in the Doc's opinion. In fact, Reward Center, the company responsible for running those Asus and MSI rebate programs, says payouts should be received 8–10 weeks after your submission is approved. It even offers an expedite service if you're willing to forfeit some of your share. How generous.

Although rebates aren't a scam per se, they can be used in shady ways. There's a good chance you bought those Asus and MSI products because they were advertised with rebates, right? But many enthusiasts never submit the paperwork. Some fail to complete the forms properly, disqualifying themselves. The rest are forced to wait as someone else earns interest on their money.

Typically, the Doc excludes rebates when considering components to recommend. They're often too much of a hassle. If you plan to shop with rebates in mind, though, keep copies of everything, follow instructions precisely, and be diligent in following up. In your case, Colm, www.4myrebate.com is where you want to go for claiming and tracking your rebate status.

Mystery Sounds

Hi Doc, First, I just want to say that I've been reading your magazine for many years. I

always enjoy it, and look forward to each new issue. Keep up the great work!

Now, on to my head-scratcher. Due to a failed boot drive, I had to buy a new SSD. I performed a clean installation of Windows 10 on it, which went fairly smoothly. After an afternoon or so, all of my programs were back up and running, with everything pretty much normal. The only problem now is that I randomly hear a system sound seemingly not associated with any on-screen activity.

This does not seem to be interfering with anything, it happens once an hour on average, and it's only a nuisance. But it bothers me that I can't identify the cause. I listened to all of the standard Windows sounds and determined this one is called "Windows Message Nudge." I also figured out that there is a "Windows Message Nudge" Program Event in the Sounds tab, and it was set to what I've been hearing. So, I set the Program Event to "None" and assumed I solved the problem. Unfortunately, I'm still getting the random sound, and it's definitely Windows Message Nudge. Nothing happening on-screen relates to the sound. In fact, my monitor might be blank with no programs running, and I still hear it.

Although I realize there are many processes running in the background that could be causing this, I'm at a loss as to what I can do. A Google search turns up nothing, and I've posted on several technical forums (including Microsoft's) to no avail. So, I turn to you for assistance. Any help is appreciated.

—Gerry Exstein

THE DOCTOR RESPONDS: If you have gone through the entire Sounds tab and are certain no other events are set to use Windows Message Nudge.wav, a third-party application must be triggering it.

Although you mentioned performing a clean Windows install, it also sounds like you spent some time restoring apps



Beyond backup, QNAP's TS-453A enables accelerated encryption, 4K video playback, and more.

that were on the PC before its boot drive failed. Might one of these have been the Rainmeter desktop customization tool? An optional skin for that software is reported to trigger Windows Message Nudge on an hourly basis, according to the Doc's research.

Dropping Standards

Recently, I noticed that a lot of PCs don't come with power supplies sporting 24-pin ATX connectors. I have a Dell Precision Tower 3620 with an eight-pin connection, a Dell Inspiron 2668 with a six-pin connection, and a Lenovo ThinkCentre M710T with a 10-pin connector. One common attribute between them is that their power cables for peripheral devices come from the motherboard, not the PSU.

Dell has its own stickers on the PSU, but Lenovo is using a Lite-On power supply. I couldn't find anything on Lite-On's website. All it gives you is a phone number to call. I tried to get information from EVGA, but it didn't know of any new PSU standards.

Is this, in fact, a new standard? If so, what is it called, so that I know what to buy from Corsair, EVGA, or another manufacturer. I'd like to have a spare on hand.

—Leon Garfield

THE DOCTOR RESPONDS: All three of your examples come from tier-one manufacturers so large that they do not need to abide by standards in their PCs. In order to facilitate unique form factors, minimize costs, and simplify assembly, those Dell and Lenovo desktops incorporate compact PSUs able to deliver just enough power to drive the components

available across narrowly defined spec sheets. And if the Doc is being just a little cynical, they effectively discourage enthusiasts from getting in there and upgrading old components, forcing you into an entirely new PC sooner.

So, in short, none of those power connectors represent new standards. Consequently, you won't be able to call up Corsair or EVGA and order a replacement. Talk to Dell or Lenovo instead. Just don't expect a replacement with enough headroom for higher-end graphics. Between the three models you cited, only Dell's Precision Tower 3620 was available with more than 300W of capacity.

There are plenty of stories online of hobbyists splicing 24-pin ATX PSUs into proprietary connectors. But many are riddled with caveats, and frankly sound pretty dicey. If serviceability means something to you, simply consider a more standards-friendly configuration next time around.

File Backup

Hey Doc! I am looking for a file backup solution. I save all my files to a separate physical drive designated "S:\ File Saves," and redirect my Documents folders to that location. It also contains numerous folders with my pictures and archived programs. Right now, I do a manual periodic backup of all the folders. But what would be the best solution to keep these files backed up automatically, whether using built-in Windows utilities or other programs? I am looking for the best program for the job, whether free or paid-for.

—Dean Bouzas

THE DOCTOR RESPONDS: The Doc is, admittedly, averse to cloud-based backup, and prefers to maintain a five-drive NAS locally in RAID 5 with one hot-spare. All of his family's user data lives on that appliance, and is connected using iSCSI. Any time a drive fails, it's replaced gracefully. 🔄

BLAZING PERFORMANCE



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BUILDER'S BIBLE



Top tips and tricks to make every build as easy as can be. Dodge common pitfalls, fix troublesome boot conundrums, and enjoy every minute of your DIY system-building experience

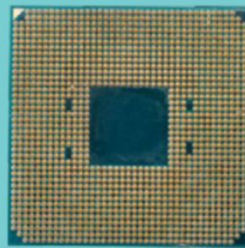
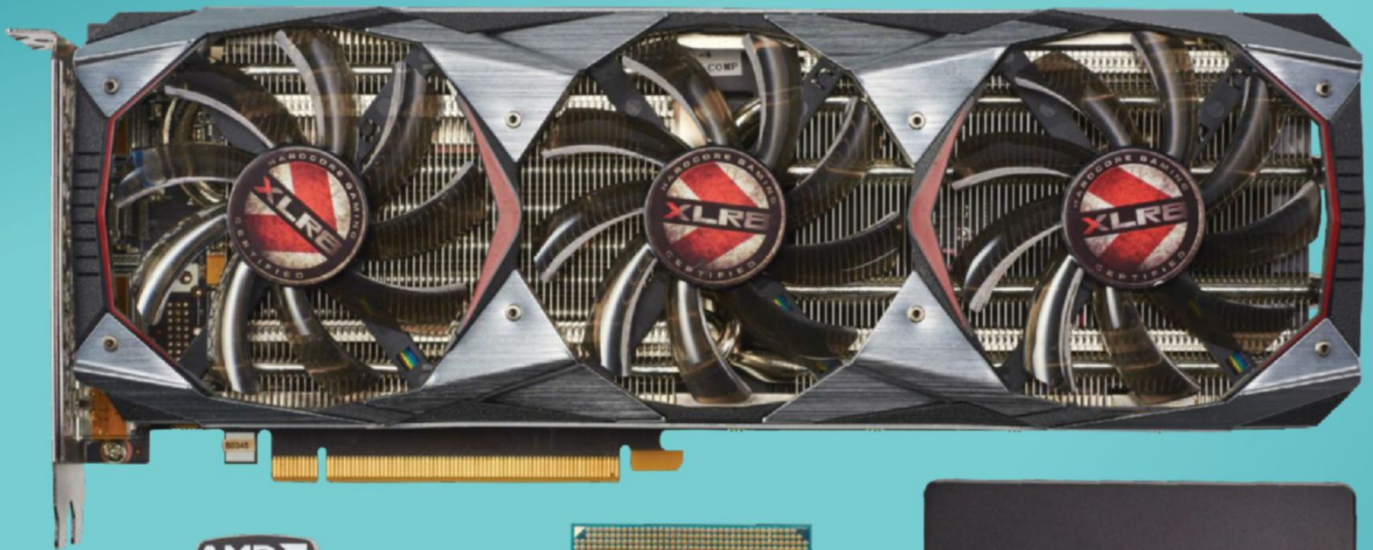
SYSTEM BUILDING is one of the central tenets of the PC enthusiast community. It's something we should all aspire to. Here at *Maximum PC*, we've built rigs and taught others how to craft their own, both in person and across these pages, countless times. And with one very good reason: You get a real sense of pride from constructing your own machine, and an even greater one from teaching others how to do it. And with the added benefits of knowing every part that goes into your build, saving some cash, and understanding how to troubleshoot your system if it goes wrong, it's hard to ignore the advantages that system building brings.

A lot revolves around system building across the industry. From hardware development, to the custom modding scene, to the liquid-cooling community, the gamers, the video-editors, overclockers, Linux users,

web developers, you name it—all of them are based around that one basic principle. And for many, it's what brought them to this community to begin with.

Yet in today's age of easy-to-construct behemoths, is there really that much hidden knowledge to be discovered when it comes to these builds? Well, from the budding builder to the artisan crafter, a little knowledge can go a long way, and even today, some of us beaten-up techies here at *Maximum PC* still learn a thing or two whenever we step foot into each issue's "Build It" feature. So, let us impart our knowledge to you. We've broken more cases, sheared off more flesh, and destroyed more hardware than you can possibly imagine. Allow us to divulge those secrets, and give you our very best tips and tricks for building your own slice of Dream Machine pie. —ZAK STOREY





THE PERFECT PLAN

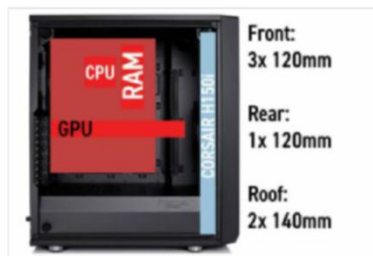
Research, plan, budget. Those are the first things you need to do when your mind wanders toward building a new rig

TIP 1 RESEARCH



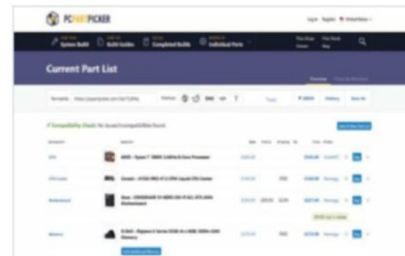
A LITTLE KNOWLEDGE can go a long way when it comes to building your perfect PC. And the best place to start is reviews. You can look at all the build guides in the world, but if you don't know what gear is right for you, you're going to end up sorely out of pocket, and with a system not fit for purpose. Reviews are a huge source of information. Whether they're online, on YouTube, or in good old *Maximum PC*, you can learn how something works, how to install it, and how it performs when push comes to shove. Second to reviews are manufacturers' websites. Reading PDFs and install manuals ahead of time will make the build process far easier, and help you set everything up after, too.

TIP 2 PLAN



NEXT UP is the planning phase. This is more of an environmental and aesthetic decision-making process than anything else. Figure out how much space you have for your new rig, where it's going to be situated, what form factor you want, and what chassis is right for you—remember, airflow and ambient temperatures are key. Then you've got to think about what hardware will fit where. Do you want a 240mm AIO up front? Will it conflict with your GPU? What will internal temps be like? Can you install it on the roof? Or perhaps an air cooler is better? All of these things can be answered long before you even take the first step into an online purchase.

TIP 3 BUDGETING



TAKING THE PLUNGE and choosing what hardware is right for you relies heavily on the first two tips. Look at what cash you have and allocate it accordingly. Make sure you buy hardware that's either appropriate for what you do today, or what you will do tomorrow. Don't allocate half your budget to cooling and aesthetics if you can get 30 percent more performance out of it elsewhere. And make sure you don't waste cash (on faster memory kits for Intel, for instance) where you don't need to. If a sale is coming up, wait for it—they're usually worth it. Hell, you can drip feed hardware, too; buy one or two things per month, instead of going all-out in one go.

DIY VS. PRE-BUILT

We're in an odd place with pricing, and that old adage, "It's always cheaper to build your own rig," doesn't hold true right now, at least, not until Samsung and co. get their extra memory plants up and running. The memory shortage and cryptocurrency mining have ruined it for everyone. So how can system integrators still offer us cheap pre-built machines? It's down to pre-emptive bulk buying. Most companies that offer pre-built systems buy all the hardware they need in bulk, well ahead of time, so for the time being at least, they're still running off older prices, and can drastically undercut the current market.

Usually, the longer a memory standard has had to mature, the

cheaper it becomes to produce, so the market stays ahead of the system integrators. But given current circumstances, that's just not possible.

That's not to say that system integrators don't provide decent systems. Some of the best machines we've seen come from the likes of Falcon Northwest, Digital Storm, and others. After all, when your livelihood revolves around building unique, bespoke, and powerful machines, you're going to learn a thing or two about putting together a stunning rig. Couple that with extensive parts and labor warranties, and they immediately become very attractive propositions, especially if you don't have the time or inclination to build your own.



TOOLS OF THE TRADE

Nowadays, all you need to build most systems is a good old trusty Phillips head screwdriver, but here's a selection of the other frequently used tools and handy gadgets we turn to in our PC-building escapades

MAGNETIC BOWL You can pick up this handy Park Tool magnetic bowl for a little under \$10 from Amazon. Amazingly useful for storing all your bolts and screws, you can attach it to anything metallic, at any angle, without the worry of losing any of the stuff inside. Plus, rub your screwdriver up against the bowl, and voila—magnetic screwdriver. That's science, folks.



THERMAL PASTE We stick with one brand: Noctua's NT-H1 Thermal Compound. It's a non-conductive thermal paste, with a satisfying consistency, which doesn't spill out all over the place. You're not going to see revolutionary changes in temp with a higher quality paste, but you will see some. Just make sure you don't use conductive paste, but if you do, be careful when applying it to your CPU.



CABLE TIES Amazon will happily sell you 300 of these for about \$9, and they are, by far, the most useful PC building accessory you can own. Whether it's tying up spare cables, strapping cables to your frame, or jerry-rigging all sorts of mounting procedures for less-than-amiable products, the humble cable tie is clean, easy to use, and one of the most versatile tools on the planet.

ISOPROPYL ALCOHOL

For less than \$4, this is one of the few liquids that won't kill your hardware if it gets on it—99 percent alcohol is fantastic for cleaning off cruddy thermal paste, and is generally a good cleaning agent to get rid of smudges on almost anything (aluminum included). Just don't rub it on soft plastic stickers and the like. Or inhale it. Or get it on your skin. Or try to drink it. Seriously. Just be careful.



SCREWDRIVER & SOCKET SET A decent set of screwdrivers will make builds far easier. Get a good kit with a variety of different sizes. Whether it's torque screws, tiny M.2 screws, standoffs, Allen screws, or even proprietary hex screws on the back of GPUs (here's looking at you Nvidia), a good set will cost you about \$40, but potentially last a lifetime.

CHASSIS STRIPDOWN

So, you've bought all the hardware, your tools are prepped—what's the next step to ensure your build is as easy as it possibly can be?

TIP 1 CASE STRIPDOWN

THE FIRST THING to do (other than lay out all your hardware, and take a shot for Instagram, obviously), is strip your case down to its frame. Carefully unscrew, pop off, and remove every panel you can find. You can also remove the dust filters, and any hard drive cages you don't need. Doing this improves airflow, makes your build infinitely easier to manage in the early stages, and stops you manhandling and potentially damaging some of the more aesthetically pleasing panels (damn you, brushed aluminum).

TIP 2 PANEL STORAGE

IT'S SMART to keep your part boxes, at least for a year or so, until the warranties run out. That said, there's an immediate use you can make of the box your chassis came in. The larger side panels and glass windows can slot carefully into your cardboard case box, between the polystyrene packing material, to ensure they don't get damaged or lost. You'll know where they are, and you can rest assured they're not going to fall over or get scratched during the build process.

TIP 3 MEDITATE

NOT REALLY, but you should visualize where your hardware is going to go. This is a great time to do a test fit—place your hardware where you think it'll go, and check there won't be any problems or conflicting parts. Imagine your cable routes, check there's enough room for your fans; it'll save time in the long run.



TIP 4 REPLACE THE STOCK FANS

MOST STOCK FANS are more than adequate for providing some sort of cooling, but if you have an eye for detail, you prefer more performance-oriented fans, or you're just after something that's a little quieter, replacing those stock polypropylene blades now is definitely the best decision. With unfettered access to every area at this point, it's easy to route the cables behind your case, and install them without worrying about the chassis being too heavy when everything's inside. One thing we would say is that you should wait until later to install any AIO liquid coolers, because the waterblock and tubing will only be a nuisance during the installation process otherwise. Also, if the top of the chassis is pretty tight, it might be worth holding off on those, at least until you've had the opportunity to plug in the motherboard power cables, and any other fan cables you're going to need.

TIP 5 PRE-THREAD YOUR CABLES

WHEN WORKING with more budget-oriented cases, with little cable management room, pre-installing and threading your cables ahead of time is a smart way of making a cleaner, tidier build, without necessarily breaking the bank. One particularly problematic cable tends to be the eight-pin EPS, or CPU power. For cases without any cable routing room, you can actually lay the CPU cable under the motherboard itself and into the top left-hand corner of the case. Then, after you install and secure your motherboard down (not forgetting the I/O plate, of course), you can plug in and install your CPU cable, keeping it out of the way and tidy in the process. In pricier options, and with modular power supplies, now is the perfect time to decide what cables you're going to need, and pre-install the lot, tying them to the back of the chassis where you can, using the cable ties we mentioned earlier.

COOLING MASTERY

Making sure your rig can handle the thermals thrown around inside is imperative, so how can you alleviate these conundrums ahead of time?



TIP 1 RIGHT FAN FOR THE RIGHT JOB

IF YOU'RE LOOKING at maximizing your cooling efficiency, selecting the right fan for the right job is critical. There are two types of fan design: static pressure fans (with fat, thick blades), designed for high-pressure environments, where they need to push air through radiators or heatsink fins efficiently; and airflow fans (with multiple skinny blades), which are designed to move as much air through a system as quickly as possible, but without the same amount of force as their static pressure cousins. At the very high end, you'll find some static pressure fans that can shift as much air as an airflow fan, but that comes at a cost (\$25-plus per fan). Noise is also a factor. The bigger the fan, the slower the RPM usually, and the less noise. Typically speaking, if you're after a quiet rig, look for fans that operate below the 1,200rpm mark. You can control faster fans through the BIOS or a fan controller to go slower than the advertised speed, but you may encounter coil whine because of it.

TIP 2 COOLING WITH STYLE

SO, HOW DO YOU cool your processor? Well, it's down to personal preference and your

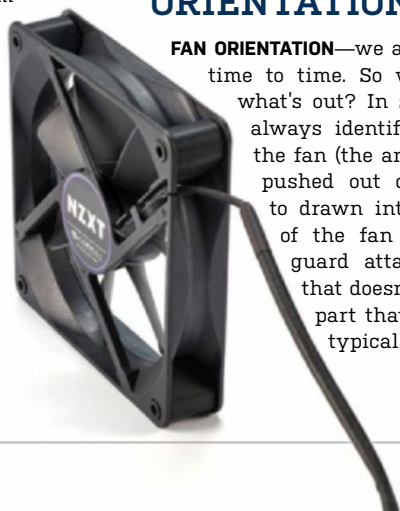
CPU. With most mainstream, locked Intel processors, you can get away with the stock heatsink. If you prefer things more chilled, grab an aftermarket air tower. But there's nothing to say you can't use a 240mm AIO on a Core i3 or Ryzen 3. Any Intel K series processor at an i5 level, or Ryzen 5 or higher, should be cooled by a substantial tower solution or a minimum of 120mm liquid cooler (\$50 or more). If you intend to overclock, this is a must. For Core i7 or Ryzen 7 and higher, with overclocking, use a 240mm AIO or \$70 air tower. If you've not got much space, or limited intake, we recommend an air cooler over the all-in-one.

TIP 3 AIR PRESSURE

YOU'VE GOT the right fans and CPU cooling, next up is internal case air pressure. There are two trains of thought: balanced and positive. Balanced means you're drawing (roughly) as much air in as you are pumping out, while a positive setup means you're drawing more air in than you're pumping out. Positive, in theory, stops dust entering through unfiltered areas, while a balanced system is better for airflow and temperatures. We're talking four or five degrees at most. Try both: Using benchmarking tools, put your system under strain, read the resulting temperatures, and decide which you prefer.

TIP 4 FAN ORIENTATION

FAN ORIENTATION—we all slip up from time to time. So what's in, and what's out? In short, you can always identify the back of the fan (the area air is being pushed out of, as opposed to drawn into) as the part of the fan with the fan guard attached to it. If that doesn't help, it's the part that the fan cable typically comes out of.



ACCESSORIZE YOUR COOLING

OK, we're talking about RGB. Why, when it's something we actively try to avoid? And how is it related to cooling? RGB fans are all the craze right now. We've seen plenty of LED fans in the past, but they typically only featured one color, and not the crazy cornucopia of rainbows that are now the norm across the industry.

We get it: Some folks enjoy being able to light up their rig in all sorts of weird and wonderful ways. But when you're trying to do it with fans, you have to include an additional cable that connects elsewhere (either into a fan controller, an included RGB controller module, or directly on to the motherboard). That's another cable to route, and added bulk to work around the back of your rig.

It's something you need to take into consideration if you plan to invest in these things. As far as performance is concerned, there's a minimal impact on the fans. Admittedly, some blades do have to be constructed from a more transparent polymer, to allow the LED light shine through, but that's all there is to it. Static pressure, airflow variants—they're all there, albeit not to the standard of some of the more premium offerings.

If you're itching for both performance and the ability to take part in the RGB phenomenon, Phanteks will sell you an RGB fan frame (which, admittedly, even we think is cool). Known as the Halos series, they come in both aluminum and plastic variants, and light the blades up in a very smooth pattern, while remaining pretty classy in the process—however, they only fit 120mm or 140mm fans right now.

GENERAL BUILD TIPS

Brushing up on the basics is a smart move from time to time—things change, methods adapt, and standards morph

TIP 1 AMD CPU INSTALLATION



OUTSIDE OF THREADRIPPER, AMD has stayed with the PGA (or pin-grid array) setup—the interconnect pins between the motherboard and CPU lie on the processor, as opposed to the mobo's socket, meaning fewer broken boards. To install your AM4 processor, match the golden corner on the chip with the corner on the socket. Lift the retention arm on the socket, carefully slot the processor into place, push it down firmly in the middle until it's secure, then bring down the retention arm to lock it into place.

TIP 2 INTEL CPU INSTALLATION



TO INSTALL ANY LGA processor, lift the retention arm out and up, then lift up the bracket, leaving the protective plastic covering inside. Line up the processor's golden triangle with the etched triangle on the socket, gently drop it into place, then give it a tiny wiggle to make sure it's secure. Bring the socket bracket back down, securing it under the Torx screw, then bring the retention arm down, and lock it in place. The plastic cover pops off on any LGA 115X platform, but you need to give it a bit of a tug on the 2011 sockets.

TIP 3 THERMAL PASTE APPLICATION



IF YOU'RE BUILDING a Ryzen or Coffee Lake system (or any mainstream CPU build), a small pea-sized dot of paste in the center of your CPU is all you need. If it's a larger processor—one of Intel's Extreme Editions, for instance—use two pea-sized dots, and three for Threadripper, down the center. This should be enough to ensure that any CPU heatsink, fan tower, all-in-one, or water block has sufficient thermal interface material to transfer heat away from the CPU die, across to the outer extremities of the heatsinks.

TIP 4 MEMORY INSTALLATION



INSTALLING MEMORY correctly is fairly straightforward. Find the notch on the bottom of each stick of memory, line that up with the notch in the memory slot on the motherboard, and carefully push it into place, making sure the clips on either edge of the memory slot are sticking up—these click into place once each stick is secure. Be sure to populate the color-coordinated memory slots, to ensure dual-channel or quad-channel support is operating correctly. If uncertain, refer to your mobo manual.

TIP 5 M.2 INSTALLATION

INSTALLING THE WORLD'S LATEST and greatest M.2 PCIe SSDs varies depending on which motherboard you're installing them on to. Some come with heatsinks, some don't. But the basic theory is pretty simple: Use a small screwdriver to unscrew the tiny Phillips screw that holds the M.2 down, line up the M.2 connector with the slot, and push it into place until it clicks in. Then line the end up with the mounting point at the other end, and secure back down with the tiny screw. You may have to move that mounting point depending on the length of your PCIe SSD, and there may be an additional heatsink you need to add before resealing it (remember to remove the thermal pad's sticker first), but that's all there is to it.

TIP 6 PCIe INSTALLATION

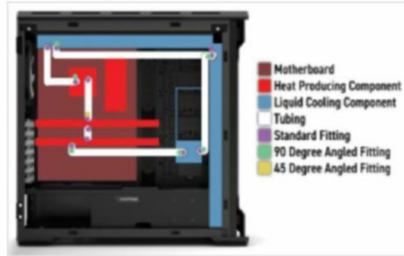


WHEN IT COMES to installing graphics cards and other add-in PCIe cards, first remove the rear PCIe covers from your case. Then, carefully line your card up with the PCIe slot on your motherboard, and gently push it into place until it clicks down. Make sure you install your GPU into the topmost PCIe slot for the best performance. There are different lengths of slot suitable for different purposes. PCIe x16 are the longest slots, designed for GPUs. You may find that some slots that look like PCIe x16 slots are actually x8 instead. You can decipher this by identifying whether the pins inside the slot go halfway or all the way to the end.

ADVANCED BUILD TIPS

So, that's the basics dealt with, but what about some more advanced tips and tricks for the would-be liquid-cooler, the OCD-oriented cable tweeker, and the avid overclocker? Never fear—we have you covered

TIP 1 LIQUID PLANNING



A FULLY CUSTOM LOOP is something most PC builders aspire to at some stage. Whether you're keen to try it or not, knowing how to build one successfully is a key piece of knowledge to have. As with most builds, it all starts with a good plan, some acquired knowledge, and a touch of research. There are two basic principles to remember when liquid-cooling. Firstly, your pump must almost always be gravity fed by a reservoir, and secondly, each component you wish to cool must have at least 120mm of radiator to support it—more for overclocking. Once you've got that pinned down, it's on to the planning stage. Similar to our first plan we did back on page 28, it's a good idea to use a side-on image of your case, sketch out roughly where your CPU and GPU will be, and work from there. By

that we mean decide where to place your radiators, reservoir, and pump (or pumps, if you're going for dual loops), then figure out how to run your tubing. Visualize your build, understand what direction the coolant will flow, then decide on your tubing runs. For beginners, we recommend keeping it as simple as you can at first, until you get the hang of it. If you intend to introduce a bend to your tubing, it's easier to work one into a long length than a short one, and it's always advisable to use angled fittings wherever possible, to reduce the number of bends you'll have to produce.

TIP 2 CABLE MANAGEMENT

GOOD CABLE MANAGEMENT is all about layering. Identify what cables need to run where, then layer them. Most cases have more than enough room in the back to allow for cable management. Zip-tie bunches of them to the back of the motherboard tray, or use the Velcro straps often included in today's cases. Tie down your 24-pin and 8-pin CPU power first, then work on PCIe cables, and anything else afterward. Modular power supplies are a must—minimizing the number of cables you have keeps a build tidy.

TIP 3 PRO LIGHTING

GOOD LIGHTING is hidden lighting. The aim is simple: Anything that produces light should be hidden, so you can only see the light that is thrown, as opposed to the light source itself. Hiding strips along the edges of cases, hidden by the thick black borders of tempered glass, or along the bottom of a chassis away from prying eyes, is a smart way of achieving this. On top of that, two strips are often better than one. Put one along the bottom and another along the front side, and you'll immediately light up two separate angles, producing a more dynamic lighting effect. Additionally, always go for a white light. Single-color strips (red, blue, green, and so on) typically drown out all definition and design on components. If a motherboard has red and black accents, and you throw a red LED strip in there, all you'll see is red everywhere.



CUSTOM LOOP COSTS & MYTHS

It's the big question that's continually asked: Is liquid-cooling worth it? At least on a custom scale? Well, that depends. You'll definitely get lower temperatures by taking advantage of that thermal heat dispensing method, but your hardware won't run any faster because of it. The one big advantage is a reduction in overall noise, thanks to the opportunity to run your fans more slowly. However, the cost is huge in contrast to more traditional cooling

methods—for a really good-looking loop, you can expect to spend anywhere between \$400 and \$600 at a minimum. Compare that to a well-armed AIO, and it immediately becomes less attractive.

So, is it worth it? You need to consider your available budget and how much you covet silence and cooling. If the answer is "A lot," then liquid cooling is for you. If not, a good old air tower or AIO with some quiet fans may be a cheaper solution instead.



FIXING BOOT ISSUES

We've all been there: the panic, the tentative push of the "On" button, the silence of zero boot. Here's a few quick solutions



TIP 1 IT'S PROBABLY MEMORY

THE NUMBER OF TIMES we've fixed a boot issue due to memory is staggering. A good way to diagnose these conundrums is via the on-board mobo debug code display. It typically displays a number, depending on the running state of your motherboard. If nothing appears on your screen, and everything's plugged in correctly, check the BIOS debug code for your first hint; 90 percent of the time, it will say it can't detect the memory. Your best bet? Reseat the memory. If that doesn't work, reseat the processor. And if that doesn't work, try moving your memory to the additional memory slots. If you're still not having any luck, it's

time to work out whether your memory is DOA. To do this, you'll want to try each stick separately. And if you're still not having any luck, it's probably time to RMA those suckers.

TIP 2 RMA & RETURNS

THERE'S A REASON we suggest going with named brands: warranty. EVGA's warranties and customer service are legendary, same goes for Corsair. If you've got an issue, raise a ticket with the customer support team, and given the evidence, it will likely exchange your part for a fresh one. So, if common sense, the manual, or Google fails you, RMAing might be the way to go.

TIP 3 FRESH INSTALL WINDOWS

WE'VE ALSO SEEN our fair share of OS-related issues, especially when transferring old hard drives to new systems. It can be anything from driver conflicts (always uninstall AMD/Nvidia drivers before swapping to the competitors cards), to corrupt OS files, to program conflicts. Ultimately, we always recommend you do a completely fresh install of Windows on to your SSD—not a refresh, not a reset, but a completely fresh install.

TIP 4 CABLES, CABLES, CABLES.

WE'VE ALL DONE IT—forgotten to plug in the PCIe power, not attached front panel connectors, had a cheap DisplayPort cable.... You can guarantee all of us here have probably built a system and missed plugging a cable in at least once. Display connection cables, in particular, are chronically bad for this—the number of crappy DisplayPort and HDMI cables we've handled over the years is horrific. In short, make sure everything's plugged in where it needs to be, and your system hasn't gone to sleep in the process.

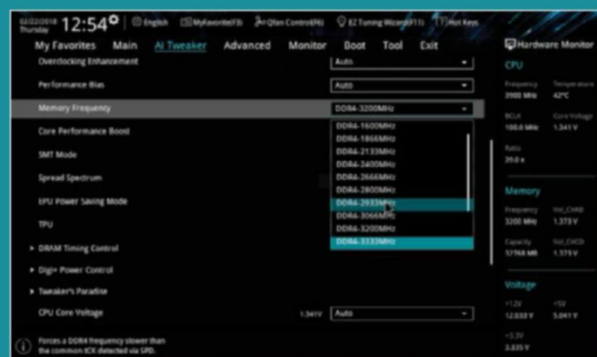
AUTO OVERCLOCKS

Nothing says "problematic" quite like an auto-overclocking motherboard. We've seen it across multiple generations now, as manufacturers try to differentiate their motherboards from each other. It's pretty prolific with Coffee Lake, as Asus pumps up the default VCore in its motherboards to boost processor performance in benchmarks (in short, enabling more stable turbos at higher frequencies at stock). This is great, up until you start noticing temperature

spikes of 20 degrees or more compared to the competition.

We've seen this with memory profiles, too. Early on with AMD memory, frequency support was haphazard across a swathe of motherboards, with 2,400, 2,800, and 3,000MT/s causing boot loops and more. Threadripper still can't support 128GB of DDR4 at 3,200MT/s.

So, what's the solution? BIOS tweaking. If you're having thermal issues, check that your heatsink is securely fastened to the motherboard;



if it is, adjust the VCore in the overclock settings. Typically, we recommend 1.2V for most Intel Sky Lake, Kaby Lake, and Coffee Lake products. For

memory frequencies, try enabling the XMP settings, and dropping the frequency by 200MHz or so to alleviate some overclock conundrums.

INSTALLATION PROTOCOL

Whether you're building a brand new rig or refreshing an old one with a clean build of Windows, you'll find our invaluable installation guide will leave your system running as smooth as silk

TIP 1 UPDATE THE BIOS

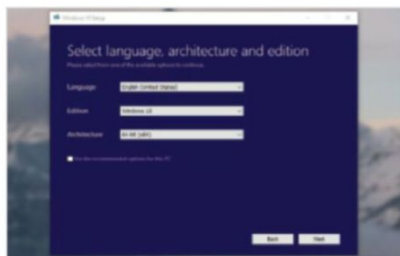
BIOS UPDATES used to be a daunting experience, leading to bricked mobos and dead CPUs. Now, it's really beneficial, and we recommend you update your BIOS whenever a new one launches. Go to your mobo manufacturer's website, find the page for your model, and head to the support section. Go to driver downloads, and search for the BIOS subsection. Download the latest version. Extract this file on to a 4GB USB stick that's been formatted to the FAT32 filesystem, then plug it into the back of your motherboard, head into the BIOS, and find the update BIOS tool in the advanced menus. Select the USB stick, find the file, and load it—your motherboard takes care of the rest.

TIP 2 FAN CURVES

WHILE YOU'RE IN THE BIOS, take a look at tweaking the fan curves. If you're plugging all your fans into PWM headers, setting a quieter fan curve can reduce noise, and make your PC experience far more enjoyable. It varies from board to board, but we recommend you set a low curve (35 percent power) all the way up until you hit about 60 C, at which point, you can start ramping up those curves.

TIP 3 INSTALLING WINDOWS VIA USB

INSTALLING A FRESH COPY of Windows 10 is fairly simple nowadays, especially if you've kept your digital key, or your Windows 10 license is linked to your Microsoft account. Head to <http://bit.ly/Win10MediaKit>, download the Media Creation Tool and Create Installation Media on to an 8GB USB stick. Plug the USB stick into the back of your system, go into the BIOS boot order, and boot from the USB stick. From there on out, follow the prompts. You're asked to sign into your Microsoft account during the installation process; you can do this now, or create a local account and deal with it later. Once logged in and on the desktop,



you can type "Activation" into the Start menu, and either log in to your Microsoft account to verify your new install, or insert your Windows code—and you're done. If you have access to the Internet, now is a good time to install any updates.

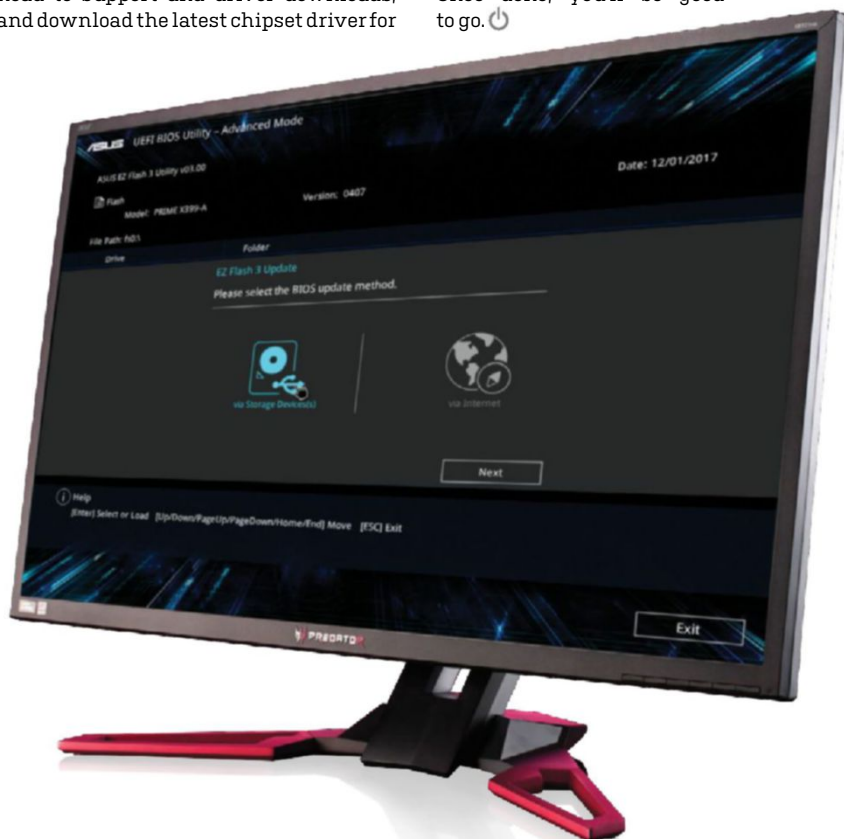
TIP 4 INSTALLATION PROCEDURE

WHAT'S NEXT? Chipset. Head back to your motherboard manufacturer's website, head to support and driver downloads, and download the latest chipset driver for

your rig. Once you've got that, download any additional drivers or utilities you may need. For a lightweight build, all you really need is the LAN and audio drivers. Install the chipset first, then hit "Restart." Now you can install the rest. Next, grab your graphics drivers. By default, Windows installs an older driver variant through Windows Update. Head to www.geforce.com/drivers or <http://support.amd.com/en-us/download>, and download the latest driver for your card.

TIP 5 NINITE

FINALLY, IT'S TIME to install any programs you need. Ninite (www.ninite.com) is our go-to tool for the quick installation of essential apps. Choose what programs you want, and install directly to your C drive. Ninite only installs to C, so if you want to keep Steam on a separate drive, pass on that, and install it separately. Once done, you'll be good to go. ⏻





WINDOWS SERVER VS. NETWORK ATTACHED STORAGE

In the blue corner, Windows Server; in the red, an open-source NAS. The only way to see which is best: a fight!

WE'RE RIDING your easily manipulated machismo as an excuse to look at the pros and cons of using Windows as a home server. The demise of the real Windows Home Server line in 2011 left a hole in Microsoft's range, one that Windows Server Essentials could never quite fill with its small business remit, at a time when, annoyingly, a home server is of more use than ever.

We all have so much digital "stuff" that we want to keep, access, stream, share, and keep safe, that it's hard to know where to put it. Sure, there are cloud solutions, but who knows where your data is going to end up being stored? Plus, access speed is always limited by your upstream/downstream speeds. So, while throwing stuff up to

the cloud is useful, there are limitations and concerns with third-party services.

There's nothing better than having real bare-metal in your locality, running services for high-speed access and backup, from where it can be pushed over slower connections to the cloud if you want. The question is, is it better to run Windows on your home server box, or is an open-source solution preferable? We're here to find out, and explain how to set up your own box.

You know we already know the answer, but we're going to do a fair and balanced test. By comparing what an open-source network attached server OS can accomplish against Microsoft's Windows 10, we can at least play with something interesting and free.

BY NEIL MOHR

WHAT IS A NAS? Network attached storage is, in some ways, an outdated term, because a “NAS” these days does a whole lot more than just store files. That’s the motivation behind this article: Can a modern NAS, even a free open-source implementation, take on the might and flexibility of a full-fat Windows box? A huge chunk of that answer relies on what you want from that box.

When the term NAS was first coined, people were just happy to easily access remotely stored files (and not get nuked by the Russians), nevermind get any specific additional services. Today, people expect a NAS to provide remote management, file shares with full permissions, print services, a slew of network protocols, virtual machine support, media transcoding, media streaming to multiple devices, supporting tens of storage devices with multi-terabytes of storage, with snapshot and versioning features on top of backups, plus a smorgasbord of flexible plug-in options. But why choose a potentially limiting NAS solution over a Windows install? Let’s start by taking time to compare and contrast what both options have to offer.

HARDWARE SPECS

We’re going to look at one of the leading open-source NAS distributions, called

OpenMediaVault (OMV for short), which is available from www.openmediavault.org. This is up to version 4.0.14 (codename Arrakis, for *Dune* fans) as of the end of 2017, and only supports 64-bit hardware—older 32-bit hardware needs to fall back to version 3.036, from mid-2016, which isn’t ideal. It does support ARM processors, and it has builds for the popular Raspberry Pi 2 and 3, and ODroid SBPCs. Beyond that, requirements are minimal: 256MB of memory and 2GB of drive space. The system is designed to run “headless,” so there is no requirement for video hardware, and it can run from a USB stick. For those interested, it’s based on the Linux distribution Debian, which is one of the best supported and longer running distros out there.

Windows 10 still supports both 32-bit and 64-bit processors, with a minimum speed of 1GHz. 2GB of memory is the minimum for a 64-bit system, while 1GB is required for 32-bit systems. The minimum drive space is 16GB for 32-bit and 20GB for 64-bit systems. Microsoft states a DirectX 9.0 video card is required.

We’d question both of these minimum requirements in a real-world setting, though. Windows is likely going to need at least a 64GB drive, while even OMV is going to work more efficiently with more memory

to buffer file transfers, though its storage really remains small.

SOFTWARE SPECIFICATIONS

Windows 10 wins here, right? It supports everything—what can beat that? It’s a tough unfair to compare Windows 10 Pro against OpenMediaVault. One is a consumer-level OS designed for single-user systems, and the other is based on a multi-user, enterprise-grade, open-source OS.

Both do many similar basic things out of the box, such as hardware support, user management, scheduling jobs, multi-language support, network support with IPv6, wake on LAN, software RAID, disk quotas, monitoring, and print support. The boring stuff. It’s the extra boring stuff where OMV tends to excel. For management, OMV delivers a web-based interface. Windows does provide Remote Desktop, but in many ways, it’s not streamlined for management, and only supports single-user access. OMV supports network Link aggregation for network redundancy and bandwidth improvements, Windows 10 Pro doesn’t.

INSTALLATION AND UPDATES

We’re going to just say it: OMV wins hands down here. It installs in 10 minutes or so, is up and running, and fully updated in that

HOW TO GET STARTED WITH THE OPEN-SOURCE OMV AND NETWORK ATTACHED STORAGE



1 GET OPENMEDIAVAULT
We’re assuming you’re installing this on a blank system—we’re not attempting to run anything alongside OMV, dual boot, or so on. So, we can safely wipe the entire boot system drive. You could run it off a USB stick, but an old sub-64GB SSD would be ideal. We’ll add data drives later. Head to www.openmediavault.org/download.html and download the latest ISO file. Currently, that’s v4.014 amd64 (64-bit). See the box, above-right, on how to get this on to a DVD or USB drive, and boot from it.



2 START THE INSTALL
If the target NAS PC has booted from your OMV media correctly, you should see an OpenMediaVault boot menu. Ensure “Install” is selected, and press Return. “Advanced options” has a hardware detection tool, handy for checking if your drives have been correctly identified. If your boot device/DVD isn’t detected, see the box above-right for options on boot menus and adjusting the BIOS/UEFI.



3 BASIC OPTIONS
Forget your fancy graphical installers, we’re kicking it old-school with text-based interfaces. Use the cursor keys to select options. There are some mundane options: “Language,” “Location,” and “Keyboard.” “Hostname” is the name displayed to the network. Use the default for the “Domain.” Then you need to set a “root” administrator password; you’ll rarely need to use this, but it controls system changes, and remote system log-ins (via SSH), so is recommended to ensure it’s secure.

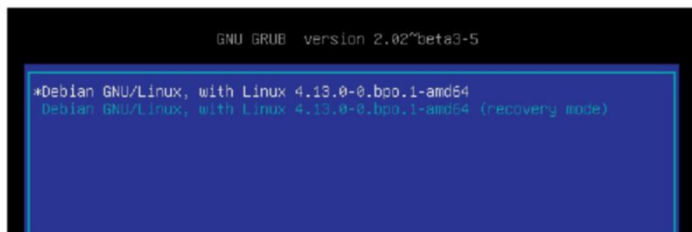
HOW TO INSTALL AN OS

Hi. If you're reading this, then you've never installed an OS before. Don't worry—there's nothing to be embarrassed or nervous about, we were all OS install virgins once. Installing an OS seems like something of a dying art; millennials and their damn embedded "smart" devices—tsk. An OS is software like anything else, it just happens that part of its job is to load the OS kernel and generally boot the system to a usable state, the clever scamp, which means that installing it requires you to boot the system off an install

media—a DVD or USB drive, in other words.

At the start of the walkthrough below, we direct you to download an ISO file of OMV. An ISO file is a standard file format maintained as ISO9660; shout out to our epic friends at the International Organization for Standardization!

To use that image, you need to do two things: burn it or write it to a suitable media, and then boot your target PC from that media. If you have DVD drives (USB DVD drives for the win), you're set, as Windows will just write that ISO to any blank disc. For USB



drives, our general go-to software is UNetbootin, from <https://unetbootin.github.io>, cross-platform, open-source ISO-writing goodness. Download, install, fire it up, ignore the "Distribution" option, jump to "Diskimage," and select the ISO file.

Now to boot from that media. Many PCs offer an early "Boot" menu, accessed by tapping

a key while powering up: F9 (HP), F12 (Dell, Lenovo), F8 (Amibios), or F11 (Award BIOS). Alternatively, use the BIOS/UEFI to adjust the drive boot order. Again, tap a key during powerup—usually Del, but sometimes F1, or F2. Some UEFI PCs require access via Windows: holding Shift, select its "Restart" option.

They say installing an operating system is hard to do....



4 ENHANCED OPTIONS
The installer attempts to set the time zone via a network connection. It's likely this will fail, so select a time zone from the presented selection—don't worry, you can adjust this later. Installation initially begins, and you're prompted to select a suitable mirror location. Do so, ignore any option for a "Proxy," and wait for the installer. This takes a few minutes; time for a cup of coffee.



5 INSTALL A BOOTLOADER
Do not enter the boot device manually. Choose the generated option below this, it should read something along the lines of: /dev/sda (complex name of your drive). If you hit "Enter Manually" by mistake, press Escape, and reselect the "Install the GRUB boot loader" option. There's a few more update dialogs, and it prompts you that the installation is done, and it can reboot.



6 IT'S LINUX!
A blank terminal—what now? It's like a choose your own adventure. OMV is designed to be controlled via a web dashboard, and for the "box" to be run headless. So, you need to discover the IP address of the OMV PC. To do this, you could use a smartphone network scanner, such as Fing, use a Windows-based scanner, such as Advanced IP Scanner, log into your router and discover the device's IP, or log in to the OMV terminal using the username "root" and your root password, then type "ip addr show." It spits out a bunch of networking nonsense, but the IP address is the second-to-last line, ending with a /24—something like 192.168.1.10/24.



7 WEB INTERFACE
OMV is controlled via a web interface—you log into this via a standard browser, running on any device, connected to your local network. In the browser's address bar, enter the IP spat out in step 6. For example: 192.168.1.10. To log in, the username is "admin" and the password is "openmediavault." Congratulations, you're up and running. You start viewing the Dashboard section, under "Diagnostics." All controls are down the left-hand menu, reboot and power controls are in the top-right menu.

time. It's licensed under the GPL v3 (copyleft open source), and based on one of the biggest Linux distros, Debian. So, as long as the project has developer support, you'll get all the updates and support you need, for free, forever. We think you know where you stand with Windows 10 on these points.

An associated issue with installation is driver support; in the past, you could have claimed Linux suffered from poorer support, but that's rarely the case now. Intel generally puts open-source driver development first; AMD is pushing its display driver stack to being entirely open source and part of the kernel. The main areas of contention are odd Wi-Fi dongles, but a touch of Google research typically unearths a Linux driver. But, then, printers and scanners can be a pain on Linux, too.

SERVICES AND ADMIN

A key differential is how OMV and Win 10 handle services and admin. With Windows, you can support all manner of services through clients, but it's all done with separate interfaces and Remote Desktop, which is hardly ideal. With OMV, all admin and services are installed and controlled through the same web interface from any network-connected device. It's the headless functionality that enables you to tuck your

WINDOWS SHARES

If you've followed the walkthrough, you're at a point where the NAS can be let loose on your network for people to access. The final step is providing shared folders for Windows users to access. This uses the SMB/CIFS, aka Samba, system. Find this under "Services > SMB/CIFS." You largely just need to hit "Enable," click "Save," then click the "Shares" tab, and add any folders you've created. Click "+Add," click "Enable," select the "Shared" folder (we create a public one in step 14), and if it should be available to everyone, enable the "Public > Guest allowed"

pull-down menu. You'll likely need to click "System Apply" once you've saved the new share's settings. If you jump on a Windows machine and peruse the network, you'll now see a new OpenMediaVault machine, and inside there is the Public folder.

Creating folders with access control is more involved, and Windows can be a bit odd with credentials on occasion. In OMV, select "Access Rights Management > User," click "+Add," and create a user with a password. If you've not already, under "Shared Folders" create a suitable folder to have restricted

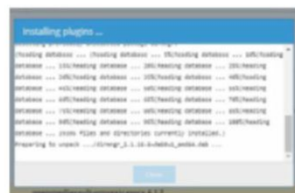


Restrict access on single user or group basis.

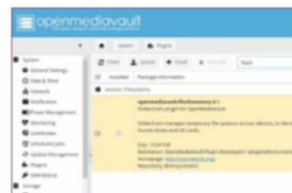
access: Click "+Add," give it a name, choose the "Device," and under "Permissions" choose "Admin r/w, Users r/w, and Others None." Click "Privileges," and choose the user and read/write access. Switch to "SMB/CIFS," click "Shares > +Add," select your new folder from the "Shared folder" list, click "Save," then "Apply."



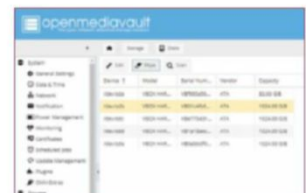
8 PLUGINS
Before we configure any storage, we're going to look at the plugin system. You add additional official and third-party extensions via the plugin system, which is basically a wrapper for the Linux software install (package management) system. Under the "General → Plugin" section, you'll find a number of default bundled official plugins. We need to add the flash-media plugin, which isn't included. Head to <http://omv-extras.org>—this is the official repository for OMV plugins. Click "Guides," scroll to "Installation," then click and download the "For OMV 4.x openmediavault-omvextrasorg_latest_all4.deb" package to your PC.



9 INSTALL THE EXTRAS
Back in the OMV interface, select "Upload" in "General → Plugins," click "Browse," locate the .deb file you downloaded, click "OK," and let it upload. Scroll to the bottom of the "Plugin" list, click the checkbox next to the "openmediavault-omvextrasorg 4.x.x" entry, and click the "+Install" button. After a few seconds, the browser reloads, and a new section called "OMV-Extras" is available. This has added a bunch of extra features, and enables you to easily add new plugins, as we'll see....



10 INSTALL AN EXTERNAL PLUGIN
If you're running OMV from a flash device, you're recommended to install the flash-media plugin. This reduces direct drive writes to extend the flash life via a memory cache. With the extras installed and a "Check" run, there's now an openmediavault-flashmemory plugin under the "Filesystems" section. This reduces the write load on flash media by caching to memory. Click the checkbox and click "+Install." With everything set, let's add some data drives and user folders.



11 ATTACH YOUR DRIVES
Power down and connect the drives that you want to store files on. We're going to create a RAID with four drives attached. These all need to be wiped before OMV will allow you to do anything. Select "Storage → Disks." Ignore "/dev/sda"—that'll be your boot drive. Select the others in turn, and click "Wipe."

OFF THE SHELF

Well, that was all a lot of effort, wasn't it? Surely capitalism can provide an easier solution? Damn right. Off-the-shelf NAS options are available in droves, and provide a level of ease, functionality, and slickness that'd be akin to the low levels of friction you'd find between dihydrogen monoxide and a mallard's back. We'd certainly point you in the direction of QNAP and Synology—both offer a range of solid NAS systems, with very flexible web-controlled software, and other simple remote management

options. You'll be able to manage your NAS from any web browser or your smartphone. At the low end, drives are typically offered in single-, dual-, and quad-bay designs, with various processor, network, video-out, and expansion options. Moving up the levels, you hit eight-bay models, with Core i7 processors, up to 64GB of system memory, dual 10GB networking, and beyond. Of course, part of the reason for running this article is the do-it-yourself option. Take an old processor and motherboard, link up a bunch of drives, and



Save a lot of time and buy an off-the-shelf solution.

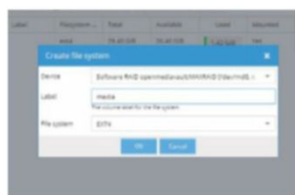
you can effectively build your own NAS box. Low-power Core i3 processors provide an excellent option and all the Quick Sync transcoding grunt you could need for most situations.

NAS away at the end of an Ethernet cable that makes everyone's life easier.

While we'd say OMV has a slightly higher entry level of required knowledge over Windows, if you're capable of installing an OS from scratch, you're going to get on with either option. You'll find help in abundance for both, while you'll balance the unbridled flexibility of Windows versus the slick stability and security of OMV. The truth is, we're all winners here; no one is forcing you to use OMV, it's just another tool in the computing armory to wield as you will. ⚡



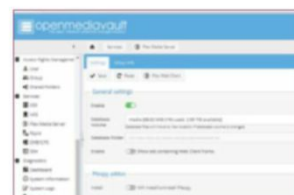
12 RAID TIME Switch to "Storage → RAID," and click "+Create." Give your RAID a name, select the drives you're going to add to the RAID, and if you're not happy with the default RAID mode, choose another. Once done, click "Create." The RAID requires synchronizing—even though it is blank—and this takes a few hours, depending on the size and speed of the drives. You'll also note the final capacity is somewhat less than the total, which is due to an entire drive being used as redundancy, so if one fails, data is not lost.



13 FILESYSTEM Once the RAID is in a clean state, you can add a filesystem to it. Under "Storage → Filesystems," click "+Create." Select your RAID from the "Device" pull-down menu, give it a name—we're case-sensitive around here—and leave the "Filesystem" as EXT4. OMV does support advanced filesystems, such as Btrfs, that support anti-bitrot checksums, among other things, but that's way beyond the scope of this article. Once created, select the new drive, click "Mount," then "Apply."



14 FOLDERS You'll want to add shared folders to keep different files for different reasons, groups, users, and so on. Have a think about who and how files will be shared and accessed. We'll create a generic "Public" to begin with. You create shared folders under "Access Right Management → Shared Folder." Click "+Add," choose a name ("public"), your RAID device, ignore the "Path," and choose "Everyone" for "Permissions." For more on network shares and Windows access, see the box above-left.



15 MEDIA SERVER Before we leave you, let's kick a Plex Media Server into action. We'll pretend everything is stored in the "public" folder (you could create "video" and "music" folders). Enable access to the Plex repositories, so we can install it. Select "OMV-Extras," double-click the "Plexmedia" entry, click "Enable, Save and Update." Switch to "System → Plugins," search for Plex, select the checkbox, and click "+Install"—this actually installs Plex. Once done, the web interface refreshes. Select the new Plex control under "Services → Plex Media Server." Click "Enable," select your main device, and "Save." Click the Plex Web Client to configure Plex. Happy NASing!

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TECH PORN



A tall, black and silver PC case, the Cooler Master Cosmos C700P, is shown on the left side of the page. The case has a silver front panel with the Cooler Master logo. The background is a solid purple color.

Cooler Master Cosmos C700P

FEW PRODUCTS IN THE PC industry have such enduring legacies as the original Cosmos. The PC ecosystem evolves at a rate unlike any other—six months down the line, and that brand new graphics card, motherboard, or processor is supplanted by something even better. The Cosmos, on the other hand? It's a legend, a perfect full tower chiseled from a block of pure aluminum, with design features well ahead of their time.

The Cosmos C700P takes that legacy and suitably reinvigorates

it for the modern era. Whether it's the intricately smooth RGB lighting, curved tempered glass, ridiculously in-depth fan controllers, inverted layouts, or cornucopia of smart features designed to make your building experience as seamless as possible, it's a chassis that really does have something for everyone.

It's costly, sure, but for such an exceedingly versatile case of this caliber, it may well be worth the plunge when looking for a full-tower chassis for your build. —**ZAK STOREY**

1 FORM & FUNCTION

Almost everything in the Cosmos C700P is secured with standard Phillips head screws. There are no pop rivets here, which means you can strip it down to the very barest of skeletons, making it exceedingly easy to reorient the internals, and mod it to your heart's content. Hopefully this is a move that the industry as a whole will adopt.

2 RGB MASTERY

For once, we're not railing against RGB. No, seriously, we don't have it lit up here, but the bars lining the roof and floor diffuse the light in such a manner that it actually looks quite classy. It's integrated into a massive fan controller, which is baked into the back of the case, and controllable through your motherboard, or via a button on the front I/O.

GAMES FOR 2018

Ones to watch from the forthcoming bumper PC gaming crop

BY PHIL IWANIUK

YOU CAN ACCUSE THE GAMES INDUSTRY of many things—and people do, just look on the Internet—but never of staying the same. It's an entertainment medium in constant flux, at once refining popular ideas and embracing bleeding-edge technology that might facilitate new ones. You wouldn't always know it by the ultra-safe parade of triple-A games that flaunt their stuff at the big shows every year, focus-grouped to within an inch of their lives, but it's true nonetheless.

Last year's biggest game was a mod based on a mod, which turned into an Early Access phenomenon. *PUBG* was as non-traditional a path to stardom as it gets, and 2018 promises more surprise hits, more genre-changers coming in from

the left field, and even some brave and ambitious titles from the big triple-A studios. The otherworldly weirdness of Hideo Kojima's *Death Stranding*, EA's indie-on-a-blockbuster-budget *A Way Out*, an actual *Monster Hunter* game on PC, and a loving renovation of *Age of Empires* all await us over the next 12 months. But will they be the ones we remember? Any one of the following upcoming titles might be the one that changes the industry, eats our free time, and becomes an all-time classic. Just wait and see.



GTR 3 TBC 2018

Back in the olden days, you could tell how serious someone was about racing games just by watching how excited they became when you uttered three letters: G-T-R. Simbin's sims were best-in-class stuff in the noughties, and the developer is back with more stern endurance series racing to show the young upstarts a thing or two. It's the Unreal Engine this time, with dynamic time of day and weather to look forward to.

» Publisher: Simbin UK
» Developer: Simbin UK



Vermintide 2

TBC 2018

More brutal co-op adventures in the old *Warhammer* universe from Fatshark in 2018, who this time swaps out the Skaven for Chaos. New maps, heroes, abilities, and enemy types are on the way, and also a particular focus on a fairer loot system. Less grinding and waiting for the RNG gods to cast their favor upon you, more cleaving skulls and laughing.

» Publisher: Fatshark » Developer: Fatshark



A Total War Saga: Thrones of Britannia TBC 2018

Total War has spanned history, and even fiction, but the formula's remained largely the same. Here's where it changes: Set after King Alfred beat the Vikings, it's a zoomed-in look at Britain, with a new tech system and mid-campaign dilemmas that may turn the tide.

» Publisher: Sega » Developer: Creative Assembly



Crackdown 3 Q1 2018

Has it been in development for too long? Once, it seemed like a sure-fire hit, but as years have passed, *Crackdown 3*'s destructible tech and open-world crime fighting are starting to look tired. Still, with Microsoft funding it, it's an outside bet to guzzle up your free hours.

» Publisher: Microsoft Studios » Developer: Reagent Games, Sumo Digital, Cloudgine, Ruffian Games



Age of Empires: Definitive Edition

February 20, 2018

That old muscle memory will be called upon again. Remember all the shortcuts? The ironically named Forgotten Empires is in charge of remastering a genuine classic of strategy gaming in 2018. 1997's *AoE* still holds up mechanically, but a new lick of paint is always welcome.

» Publisher: Microsoft Studios
» Developer: Forgotten Empires



Death Stranding TBC 2018

Is there such a thing as a quadruple-A game? If so, *Death Stranding* is the first of this new breed. Guillermo Del Toro, Mads Mikkelsen, Norman Reedus, and Hideo Kojima are all involved—makes *Call of Duty* look like a straight-to-DVD Danny Dyer movie. At this point, no one knows what it's about, except (hopefully) Hideo.

» Publisher: Sony
» Developer: Kojima Productions



Metal Gear Survive

Q1 2018

It doesn't look great. Without Kojima's visionary direction, there seems little left of *Metal Gear Solid*'s esoteric greatness in *Survive*, a sci-fi survival action-adventure. But it is a *Metal Gear* game on PC. You don't get those every day, and it'll be hard to ignore that brand power when it arrives.

» Publisher: Konami
» Developer: Konami



Anno 1800 Q4 2018

It feels as though the *Anno* series has been going since the dawn of the industrial revolution, so how fitting that this new title is set at exactly that point in time. City building with a strong economy focus and surprisingly gorgeous urban vistas, *Anno 1800* brings a story-driven campaign and longform multiplayer.

» Publisher: Ubisoft
» Developer: Blue Byte

Project Hospital

TBC 2018

Frankly, it's incredible that no one thought to set a management game in a hospital before, depict it in isometric format, and add a gentle humor to the day-to-day grind of mopping up vomit. Peter Molyneux must be kicking himself, but Oxymoron Games is pursuing this bold new vision in 2018. (OK, it's a *Theme Hospital* remake in all but name—we're fine with this.)

» **Publisher:** Oxymoron Games
» **Developer:** Oxymoron Games



Shenmue 3

Q4 2018

Ha, ha, yeah, good one. Oh, you were being serious? Well, yes, if it ever materialized, a third *Shenmue* game would be interesting. Everything about this game, though, from the strange “is it really a Kickstarter?” beginning to the three years of silence ever since—bar some screenshots and a boring environment trailer—has us worried.

» **Publisher:** Ys Net, Shibuya Productions, Deep Silver
» **Developer:** Ys Net, Neilo

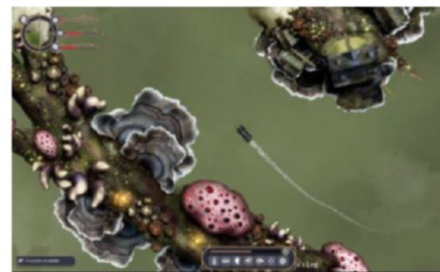


Metro Exodus

Q3 2018

Metro games are always deep, dark shooters with bleeding-edge visuals and gas masks, and *Exodus* continues that fine tradition. This time, you're on a train ride through post-nuked Russia, popping hairy mutant horrors and amoral scavengers in a series of open-world hubs. It'll be worth it for the eye-porn alone.

» **Publisher:** Deep Silver
» **Developer:** 4A Games



Sunless Skies

May 2018

Sunless Sea was an eerie and strikingly imaginative steampunk strategy about navigating the oceans of an imaginary Victorian world, forging a deeply personal story along the way. Not much is known about its sequel, *Sunless Skies*, except that it's about aviation instead of maritime exploration, and it'll probably be ace again.

» **Publisher:** Failbetter Games
» **Developer:** Failbetter Games



Ni No Kuni II: Revenant Kingdom

March 23, 2018

Look, just because he's called Evan Pettiwisker Tildrum doesn't mean *Ni No Kuni II*'s protagonist shouldn't be taken seriously. He's a king, you know. More Ghibli loveliness awaits here in JRPG form, with a new *Total War*-lite large-scale battle system, and wee chums called “Higgledies” who help out in combat.

» **Publisher:** Bandai Namco
» **Developer:** Level-5



Dark Souls Remastered

May 25, 2018

Book a vacation to Alaska and wait for the *Dark Souls* pseudo-intellectuals to wear themselves out with their seminars about From Software's adaptation of Roman mythology: It's back. One of the great action games, but in a form that runs on PC, and doesn't look like kids drew the textures.

» Publisher: Bandai Namco

» Developer: From Software



Biomutant TBC 2018

The hipster's choice for "game of E3 2017" accolades, *Biomutant* came out of nowhere last year. It's an open-world RPG, which doesn't sound very attention-grabbing, but one with martial arts-driven combat, and a gene-splicing upgrade tree. It's the colorful, whimsical world that has people in a praise frenzy, though. Will it rival *Monster Hunter World*?

» Publisher: THQ Nordic » Developer: Experiment 101



Far Cry 5

March 27, 2018

OK, so this one could go wrong. Tried-and-tested *Far Cry* formula meets plot about religious zealots in backwoods America equals... well, who knows, at this point? Hopefully, it won't just be a toothless rehash of previous successes—potentially, it's a bold and enjoyable cult-killing journey through rural Montana.

» Publisher:

Ubisoft

» Developer:

Ubisoft Montreal



A Way Out March 23, 2018

Filmmaker Josef Fares demonstrated his ability as a game director with *Brothers: A Tale of Two Sons*, and now he's back with a grander idea about two prisoners looking to make a break. Co-op and super-slick, *A Way Out* will be one of 2018's early stars.

» Publisher: EA

» Developer: Hazelight Studios



State of Decay 2 TBC 2018

It's *Dead Rising* meets *The Sims*, in the best way possible. Many games imagine zombie apocalypses, but none has gone into such detail as to how you'd rebuild society. Recruit folks and watch the effects of their decisions while you get on with the undead massacre.

» Publisher: Microsoft Studios

» Developer: Undead Labs



We Happy Few Q2 2018

Imagining a chilling dystopia in which the population's drugged into a stupor and blinded to the awful reality around them, *We Happy Few* places an unusually heavy emphasis on narrative for a survival game.

» Publisher: Compulsion Games,

Gearbox Software

» Developer: Compulsion Games



System Shock 3 Q2 2018

One of the great immersive sim series is about to get a threequel, and legendary game maker Warren Spector is involved. Can it match the impossibly high standard of its predecessors? Of course not. But it'll be great to see Otherside at least try.

» **Publisher:** Starbreeze Studios

» **Developer:** Otherside Entertainment



The Crew 2 Q1 2018

Cars? Pff. It's all about planes and boats these days, didn't you hear? Ivory Tower did, and it's adapting 2014's partially successful open-world racer over not just roads, but skies and seas, too. Plus, there's a weird *Inception*-style world-folding mechanic.

» **Publisher:** Ubisoft

» **Developer:** Ivory Tower



The Last Night TBC 2018

The Last Night wants to be *Blade Runner* with pixel graphics—that's fine by us. Odd Tales' debut combines 3D environments with 2D sprites in a way we haven't seen before, and drenches them in an eighties Ridley Scott movie color palette.

» **Publisher:** Raw Fury

» **Developer:** Odd Tales

Monster Hunter World

Q3 2018

You're already hearing all about how great it is from your console-loving brethren, so we don't need to underline *Monster Hunter World's* finer qualities as a jungle full of beauty and peril. Or as a hunting sim with incredible RPG depth. Or, indeed, as a survival game in harsh but seductive alien climes. So we won't.

» **Publisher:** Capcom

» **Developer:** Capcom



Kingdom Come: Deliverance February 13, 2018

Fanatically detailed in its depiction of medieval Bohemia, this is an RPG without dragons and elves. Warhorse has curated a huge chunk of bucolic olde worlde for you to run amok in with authentic weaponry.

» **Publisher:** Warhorse Studios

» **Developer:** Warhorse Studios



Vampyr Q1 2018

Ah, the duality of man. Poets, philosophers, and artists have been trying to capture it for centuries, but *Life is Strange* dev Dontnod has hit the nail on the head with *Vampyr*: You're a doctor, who's also a vampire. Atmospheric and bravely narrative-driven.

» **Publisher:** Focus Home Interactive

» **Developer:** Dontnod Entertainment



Mount & Blade II: Bannerlord TBC 2018

Finally, a game about frat boys slapping each other when they pass out. Wait—it's "Bannerlord," not "Banterlord." That'll be the one about recruiting an army and fighting huge battles in first-person, then.

» **Publisher:** Taleworlds Entertainment

» **Developer:** Taleworlds Entertainment

Griftlands

Q1 2018

Klei has a bit of a golden touch with 2D indies: *Mark of the Ninja* and *Don't Starve* both hail from the Canadian studio. Hopes are high for RPG *Griftlands*, then, which seduces with a sketchbook world of procedurally generated NPCs, turn-based fights, and an emphasis on subduing, not killing. So that's nice.

» **Publisher:**
Klei Entertainment
» **Developer:**
Klei Entertainment

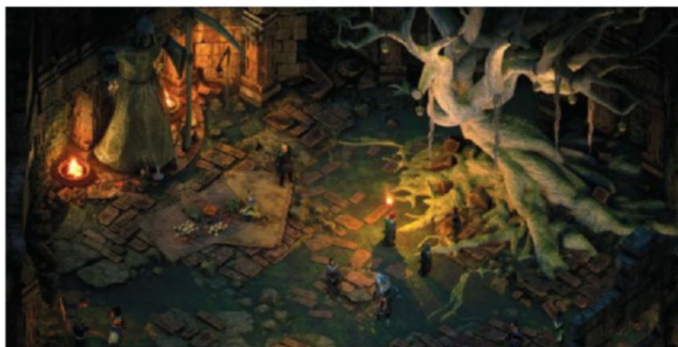


Neverwinter Nights: Enhanced Edition

TBC 2018

Neverwinter Nights is generally regarded, by people with the dice bags and books to make these calls, as the best D&D ever on PC. It's also nearly 20 years old, and looked a bit rough even on release. Beamdog, perpetual life-giver to treasured old RPGs, is dusting it off, and sprucing it up for a new generation to enjoy in 2018, and we think that's just lovely.

» **Publisher:** Beamdog » **Developer:** Beamdog



Pillars of Eternity II: Deadfire

April 3, 2018

Josh Sawyer's Obsidian team rekindled everything that we missed about the isometric RPGs circa 2000 in *Pillars 1*, and did such a good job that it's making a sequel. Dark, challenging and strictly old-school, it's one to play with copious presses of the pause button, while you issue orders, and drink in the top-notch writing.

» **Publisher:** Versus Evil
» **Developer:** Obsidian Entertainment



Insurgency Sandstorm

TBC 2018

Here to prove that modern military shooters don't all have to come from million-strong triple-A studios, *Insurgency Sandstorm* trains its laser sights on recent Middle-Eastern conflicts, and brings an indie spirit to down and dirty gunfights. Vehicular combat, spectacular fire effects, and exclusively multiplayer action await.

» **Publisher:** Focus Home Interactive
» **Developer:** New World Interactive

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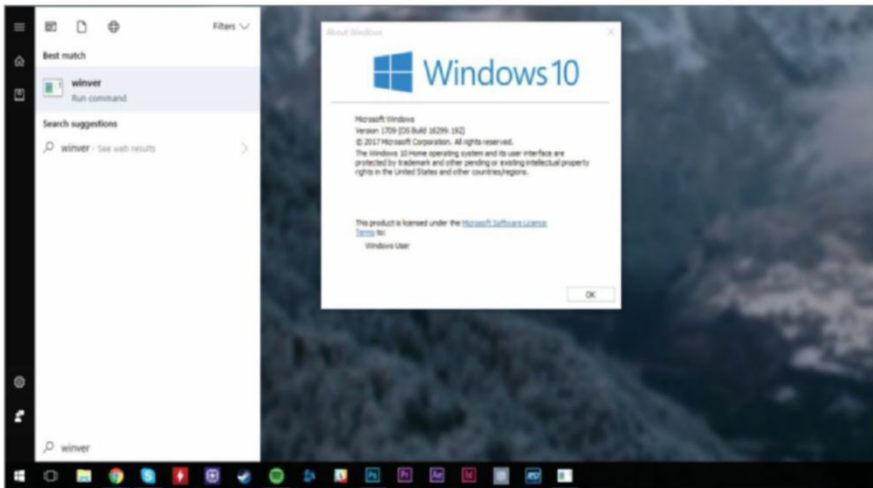
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TIP OF THE MONTH



WINDOWS VERIFICATION

We're often asked, "What version of Windows am I running?" Apart from the obvious, the version number is vital if you need to know which updates you have installed, especially in today's climate of Spectre and Meltdown. There's an easy way to find out, and get more info than the "This PC" system properties panel reveals. Open the "Start" menu, and type "Winver." This opens a window that gives you all the up-to-date info you need.

MAKE – USE – CREATE



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ZAK STOREY
DEPUTY EDITOR

PERIPHERAL PERUSAL

Work on my custom desk is under way. The bespoke steel legs finally turned up, the integrated wireless Qi charging pad has been ordered, and the overall design has been finalized. All that's left is to build the thing. But that got me thinking. I'm trying to go with a super-clean aesthetic. Ergotron's kindly provided a dual-screen monitor arm for my two ViewSonic VP3268-4K panels, to keep the huge displays off my desk. And I have some smart ideas to keep the rear I/O cables from my new rig hidden out the way as well. The biggy is peripherals—without drilling holes in the middle of my desk, it will be damn near impossible to hide those pesky USB cables from view.

There's an obvious answer: to go fully wireless. But that has its own problems. At heart, I'm still a gamer. As much as I try to deny it, I still enjoy playing pixel-driven fantasies—it's what got me into PC building. Problem is, with that comes certain expectancies. I can't just get an office Bluetooth membrane keyboard and a Logitech MX Master mouse. I need mechanical switches, and an ergonomic mouse with lots of buttons.

Right now, pickings are slim. Razer and Logitech's wireless charging mice pads are certainly tempting, but neither manufacturer meets my requirements on the keyboard side of things. And I'm still superstitious about those wireless charging pads....

submit your How To project idea to: comments@maximumpc.com



AUTOPSY

THIS MONTH WE DISSECT...



Apple TV 4K



4K HDR takes some real grunt to cool.



About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products.

To learn more, visit www.ifixit.com.

BACKGROUND

Today on our teardown table, we have a shiny new Apple TV 4K plucked straight from the technology orchards of Cupertino. So, what are we to do with Apple's first 4K HDR streaming device? Binge-watch *Stranger Things*? We definitely thought about it... but, nah, we're tearing this sucker apart!

MAJOR TECH SPECS

- 64-bit Apple A10X Fusion chip
- Gigabit Ethernet, 802.11ac Wi-Fi, Bluetooth 5.0, IR receiver, and HDMI 2.0a
- In the remote: glass touch surface, dual microphones, accelerometer, gyroscope, Bluetooth 4.0, IR transmitter, Lightning connector

KEY FINDINGS

- The newest Apple TV doesn't tower over its predecessor this time around, but we did notice a couple of key differences in the design. The bottom panel has been redesigned for what looks like some serious thermal venting. Bye-bye, USB-C port. We take a familiar access route through the underside of the Apple TV 4K. Just like with its single-K sibling, the Apple TV 4K features repair-friendly plastic clips that secure its bottom panel. No moat of glue or uncommon screws? This upgraded unit gets a 1 Up as a reward.
- Peeling back the rear panel reveals a beefy fan secured by some T7 Torx screws. After pulling them out, we meet Apple TV's biggest fan! It looks as though Apple merged the new fan with the heatsink/EMI shield assembly from the Apple TV 4th Generation, combining them to form one whopper of a cooling solution. This Voltron of a thermal assembly suggests that 4K HDR capability comes with a significant increase in thermal output. With a twist of a few more Torx screws, the assembly is disassembled, revealing a replaceable fan driven by a Nidec brushless motor.
- We're pleased to see that Apple keeps with the tradition of easily removable logic boards for the Apple TV 4K. We don't run into any surprises here; the heatsink remains much the same as its predecessor from 2015. We take a moment to pluck a familiar pair of presumed power posts from the body of the heatsink. During our Apple TV 4th Generation teardown, we suspected that power was transmitted to the logic board via the heatsink screw posts. It looks as though this is still the case with the Apple TV 4K. With the heatsink and posts out of the way, the only thing left to do is remove the power supply board.
- The new power supply is rated for 12V at 1.083A. This is just a modest bump up from the 0.917A power supply we saw in the Apple TV 4th Generation. Again taking a design lead from its older sibling, the Apple TV 4K eschews internal wiring between the power supply and logic board. The use of conductive posts in lieu of wiring probably saves internal real estate, and it eliminates the possibility of pinched or bent wires during assembly.
- Repairability Score: 8 out of 10 (10 is easiest to repair). Plastic clips hold the case together for easy opening. Modular components make for easy disassembly and repair. The power supply is modular, and features a removable AC-in jack. Standard Torx screws hold everything together. All major components are soldered to the logic board, meaning fixing any port problems will require board-level soldering or a full board replacement. 🔌

Pump Up Your Music With Volumio

YOU'LL NEED THIS RASPBERRY PI OR PI ZERO

Plus a 4GB or larger microSD card.

CABLE

Capable of connecting your Pi to an amplifier or your home stereo.

WE'RE GOING TO TRANSFORM YOUR RASPBERRY PI into a music player with Volumio, a distro that has just one job: playing and streaming music. It's relatively easy to set up, is designed for headless use, and provides a user-friendly interface through your web browser for managing your music. This UI is replicated on the official Volumio apps for iOS and Android, so you can run everything from your cell phone, too. You can also access Volumio through your mobile browser, or try an MPD-capable app, such as MPDroid for Android, instead. Note, however, that MPD apps can be tricky to set up (connecting using IP address rather than hostname is more reliable).

Volumio also doubles up as a UPNP/DLNA and AirPlay receiver, and can be used to stream music over the Internet, with built-in support for web radio, and plugins for streaming from Spotify and YouTube, too. Volumio supports the most popular audio file formats out of the box—including FLAC for those of us who have an aversion to lossy compression—and has native support for a wide range of I2S DACs for those who want to take their listening pleasure to the next level. —NICK PEERS

1 THE CABLE GUY

Check the connections on the back of your amp—typically this is in the form of two phono sockets, in which case you can connect your Pi's headphone jack to here using a suitable cable: 3.5mm plug at one end, and twin phono plugs at the other. If you only have an HDMI port, search eBay for "HDMI audio converter."

» If you want to take your music to the next level, invest in a DAC (digital to analog converter) HAT for your Pi or Pi Zero. There are plenty of options out there. The cost can be reduced dramatically if you're able to repurpose components, such as the Pi Zero W, power adapter, or microSD card.

2 GET VOLUMIO WORKING

Download the Raspberry Pi build of Volumio from <https://volumio.org/get-started>. It's around 300MB compressed. Once done, follow the main step-by-step guide (pg. 58) to copy this to a blank microSD card (4GB or larger), then complete the initial setup process. At no point do you need to connect your Pi to a monitor or keyboard, because Volumio is configured and accessed through any web browser connected to your local network.

» You're prompted to select the folder where your music is stored. Volumio can handle multiple folders stored across a variety of different locations, including on the microSD card itself (you'll be looking to invest in a 64GB or even 128GB card if you go down this route, particularly if you're a fan of the audiophile-friendly FLAC format, as we are). Because the SD format is prone to corruption, however, we recommend storing your music separately to Volumio. Suitable alternatives include USB storage plugged directly into your Pi—typically either a USB flash drive or a USB hard drive, if your music collection is on the large side. If you're connecting to the Pi Zero, you need a USB adapter or shim, and the USB drive needs to provide its own power.

» A more convenient option is to connect to network storage, which is a good way to access music stored on your main PC or a NAS drive. Volumio automatically looks for network drives alongside any locally detected storage. Don't panic if your drive doesn't show up: Simply enter its IP address or network name, along with the path to your shared music library. Use Ubuntu's File Manager to determine its name and path if necessary.

» The initial scan takes some time, particularly on the Pi Zero, and where libraries are both large and stored externally. Once initial

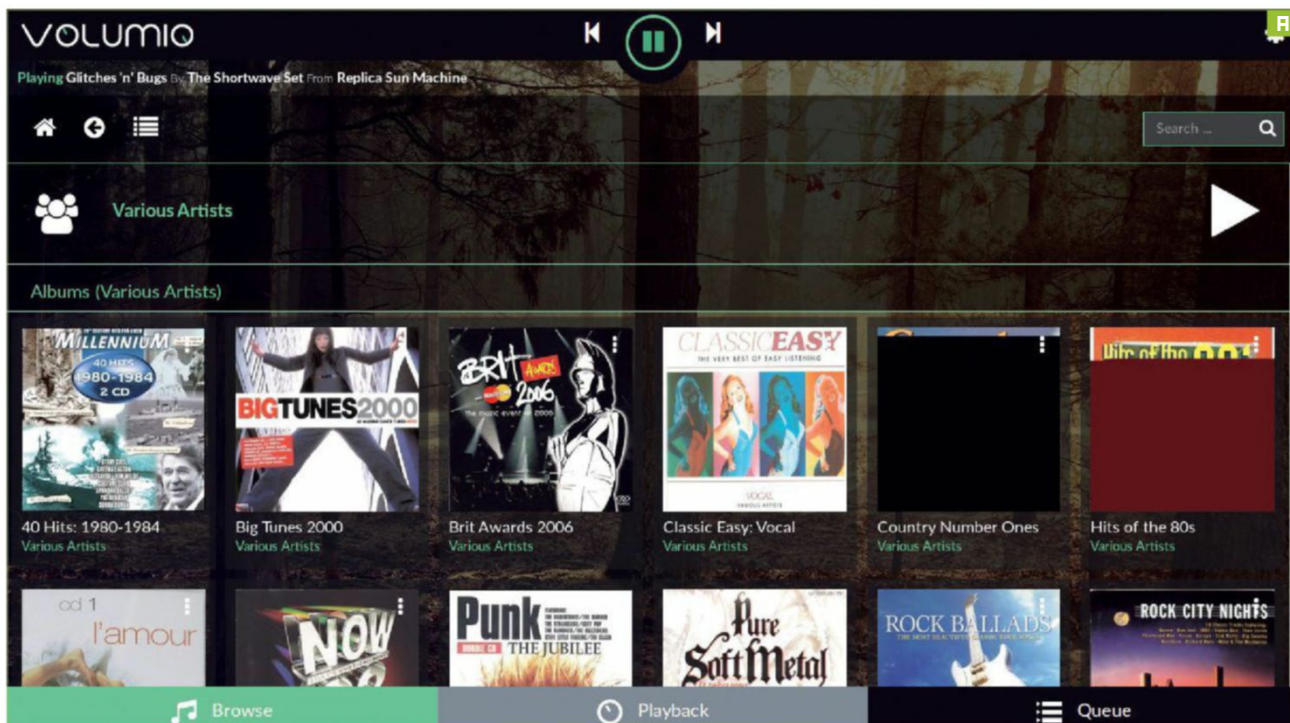
setup is complete, your browser should redirect you to the main Volumio playback screen. You'll see that it's split into three tabs: Browse, Playback, and Queue [Image A]. They're all self-explanatory, so start by clicking "Browse," where you'll see you can navigate your collection. Look out for the spinning wheel at first. This indicates that your folders are still being scanned for content.

3 CONFIGURATION OPTIONS

While you wait for the initial scan, click the "Settings" button in the top-right corner to find a range of configurable options. Start with "My Music," where you can add new drives to your library. You can also tweak other preferences here, such as whether to download album art from the web, for music folders without art in them. Consider switching this off if your album art is embedded directly into each music track (you also need to flick the "Show Embedded Album Art" switch on, then click the "Reset Album Art Cache" button). If you find that certain artwork comes up missing or corrupt, chances are there are hidden folder.jpg files in the album folder downloaded from the web. Browse to the album folder in File Manager, and select "View → Show Hidden Files" to reveal the hidden .jpg album art files. Delete these, then repeat for any other afflicted folders. Once complete, go to "Settings → My Music," and click "Reset Album Art Cache → Rescan" to update the album art.

» Select "Playback Options" to change your output device and adjust related settings. Explore "Playback Options" if you experience frequent buffering when listening to music over the network. Increase the "Audio Buffer Size" to 12MB, and consider upping the "Buffer Before Play" figure. You can tweak Volumio's volume options from here, too, such as setting a default volume on startup, or limiting the maximum volume level.

» The "Appearance" settings affect the web (and Volumio app) interface, enabling you to change language, select a background image (or upload your own), or choose a plain background color [Image B]. Access "Network Settings" to configure the wired and wireless interfaces—typically to establish a static IP address. You can disable



the built-in Volumio Wi-Fi hotspot from here for security reasons. Furthermore, there's an option to choose different DNS settings if you're struggling to get Internet access, such as those offered by OpenDNS (208.67.222.222 and 208.67.220.220).

» Select "System" to re-run the first configuration wizard, change your player name (this is handy if you have more than one Volumio-based music player), perform a factory reset, delete your user data, and check for any updates. A word of warning about this final option: It may corrupt your SD card, so always back up any user data on the card before you begin. We'll tackle this at the end of this project.

» Once backed up, open Volumio and switch to the "Browse" tab. You'll see several options for browsing your library: You can navigate by artist, album, or genre (if your files have been correctly tagged), or choose "Music Library" to browse by location. This is handy if you've set up multiple folders, and are only interested in browsing a specific one (for example, your classical music collection).

» Over time, your music folders will change, of course. You'll add new tracks, and perhaps remove others. You may also wish to manage the metadata associated with your tracks—both

tags, such as artist, track name, album name, and so on, together with artwork. None of these changes are automatically recognized by Volumio; instead, you need to manually rescan or update your library. The difference is straightforward: An update searches for new, changed, or removed content, while a rescan scans all the files in your library for changes.

» If you've updated a specific artist or album, then you'll also find a handy "Update Folder" option on the ≡ menu next to its entry. This enables you to perform a focused scan on that part of your library.

4 BROWSING AND MANAGEMENT

You will also notice options for browsing by Favorites and Playlists. "Favorites" contains a list of your best-loved tracks—these can be added manually via other views (or the "Queue" tab) by clicking the ≡ button next to a track, and choosing "Add to Favorites." Once added, just click the ≡ button once again and choose "Remove from Favorites" when you finally become sick of

WORKING WITH PLAYLISTS

Like any good music player, Volumio supports playlists, but unfortunately it's not the most intuitive of tools. Switch to the "Browse" tab, then browse your music library by either artist or album. You'll see the ≡ "hamburger" menu button next to artists, albums, and individual tracks—click this, and you'll see an option to add the selected item to a playlist. Either type the name of a new playlist and hit "New," or click an existing playlist to add the items to

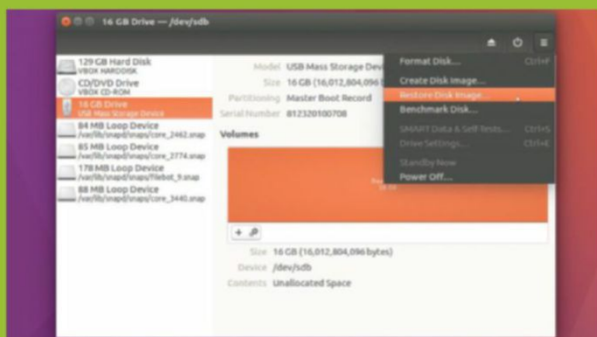
it. You can access your playlists from the "Browse" tab. From here, you can open the playlist to remove individual items via the ≡ button, but one crucial missing feature is the fact that you're unable to rearrange the running order.

No problem: A more elegant—and, indeed, quicker—method to both create and edit playlists comes courtesy of the "Queue" tab. Instead of adding items to a playlist, choose "Add to Queue" (so one click instead of two). Once complete,

switch to the "Queue" tab. Not only can you remove individual items from here, but you can click and drag them to rearrange them, too. Then click the floppy disk icon to create a new playlist or select an existing one.

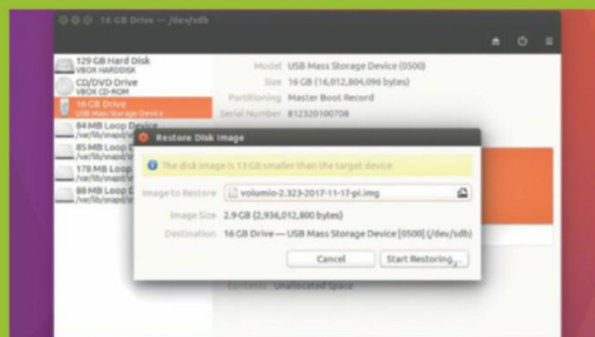
Note that your queued items aren't appended to an existing playlist—they overwrite it. So if updating a playlist, you should first select it from the "Browse" tab (under "Playlists"), and choose "Add to Queue" before making your changes.

SET UP AND INSTALL VOLUMIO



1. PREPARE YOUR MICROSD CARD

Double-click the .img.zip file you downloaded from the Volumio website to open it in Archive Manager. Click "Extract" and save the image file to the same directory as the downloaded file. Now insert an unused microSD (4GB or larger) card into your PC. Open the Disks utility, select your card, and click the hamburger-like icon. Choose "Restore Disk Image."



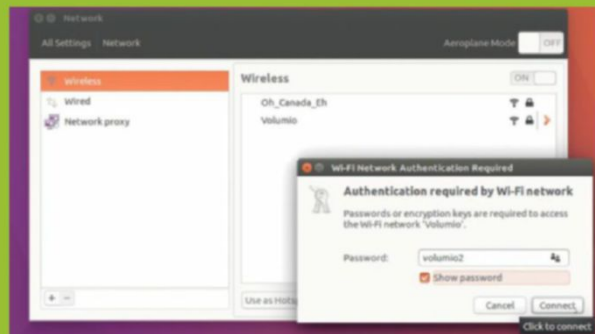
2. INSTALL VOLUMIO

Click the "None" button to browse for and select your image file. You'll receive a warning about the disk image being smaller than the target device—don't worry, Volumio expands the partition during setup. Click "Start Restoring" followed by "Restore." Enter your user password, then sit back and wait for the image to be written to the card. Once complete, safely eject the card.



3. SET UP VOLUMIO

Once complete, verify the volumes are set up correctly: a small 64MB FAT32 bootable partition, plus a 2.4GB volumio Ext4 volume, followed by a 300MB volumio_data Ext4 volume, with the rest of the drive given over (for now) to free space. Safely eject the card again, then insert it into your Raspberry Pi, and switch the power on. Wait for around 6–10 minutes while it's set up, and the free space allocated.



4. SET UP CONNECTION

If your Pi is going to connect wirelessly to your network, you'll need to first connect to its own internal Wi-Fi network via another wireless device or computer. Open the device's network properties—"Settings → Network → Wireless in Ubuntu"—and connect to the Volumio Wi-Fi network. Use the password "volumio2." Now open your browser and go to <http://volumio.local> to set things up.



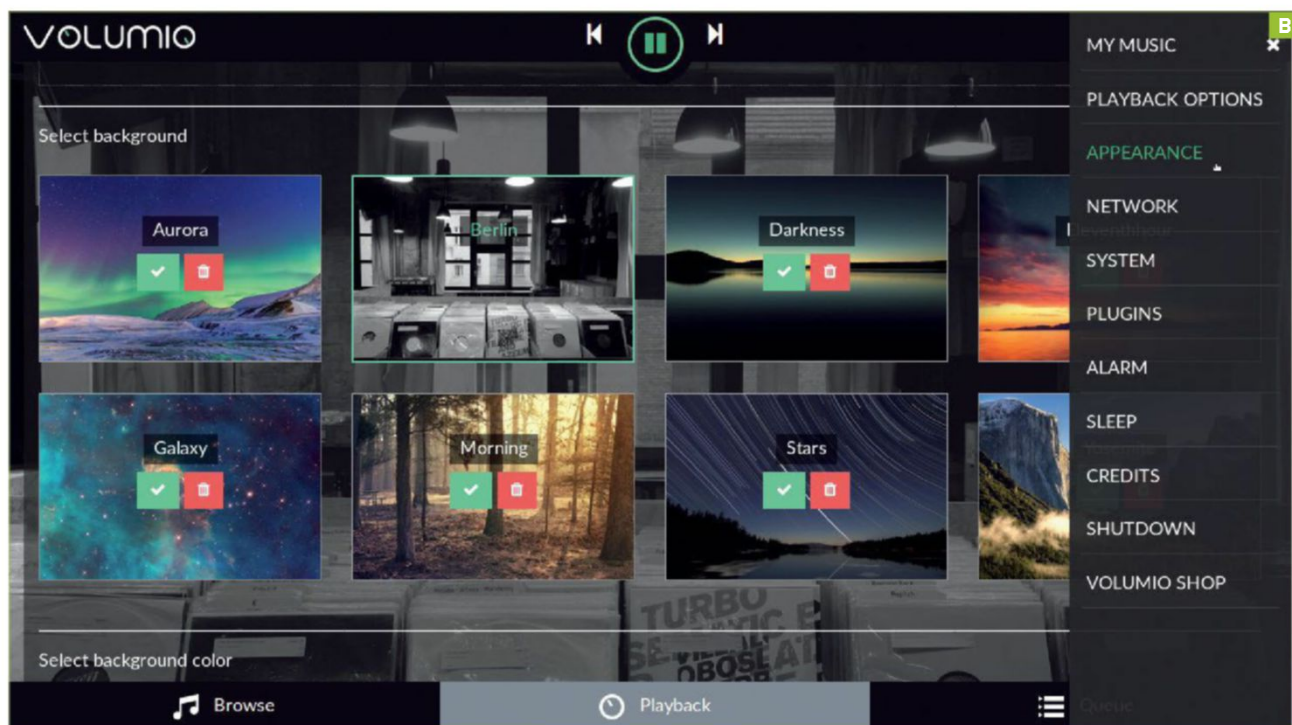
5. NAVIGATE FIRST-RUN WIZARD

A six-step wizard helps you get things up and running. First, select your language and click "Next." Give your device a unique name (in most cases, "Volumio" is sufficient—unless you have multiple devices set up), and click "Next" again. Now choose your output device. Click the "I2S DAC" switch to "Yes," then select it from the list, and click "Next" again.



6. COMPLETE SETUP

Now connect Volumio to your Wi-Fi network. Select your network from the list and click "Connect." Enter its password (ignore the warning about insecure connections—we can fix this later). Click "Next." You're prompted to set the path to your music collection—click "Add New Drive" to do so (see main text for advice). Finish by clicking "Next → Done." Reconnect your PC or device to the main network.



listening to the song. Playlists offer more flexibility, because you can generate these from entire albums and even artists, as well as individual tracks—see the box (pg. 57) for more information on managing playlists.

» Two final options include “Last 100,” which basically lists the most recently played tracks. This is a convenient way to quickly collate these into one place for the purposes of creating a playlist or favoriting specific tracks. Then there’s “Web Radio,” which gives you access to hundreds of online streaming radio stations.

5 ONLINE STREAMING

Web Radio uses Shoutcast and Dirble services for tracking down and listening to radio stations worldwide. Shoutcast offers a choice of the top 500 stations or the ability to browse by genre; Dirble offers a browse by country function. Click a radio station to start listening, add it to the queue, or make it one of your Radio Favorites.

» You can also manually add radio streams yourself by clicking ≡ next to “My Web Radios,” and choosing “Add Webradio.” Give your stream a name, then enter its URL stream or link to a M3U or PLS remote file.

» Two additional streaming services—Spotify (Premium account required) and YouTube—can also be added via “Settings → Plugins → Search Plugins.” Once installed, switch to the “Installed Plugins” tab to switch them on. You can then access them from the home screen under “Browse,” and access the content as though it were your local library, adding it to queues, playlists, and favorites (a handy search tool helps you to quickly locate content). The major difference between local music and streaming is the noticeable delay between clicking on a stream and it actually starting.

6 BEYOND THE BASICS

Plugins enable you to extend what Volumio can do. There are currently around 10 available from Volumio’s “Plugins,” split into four categories. Spotify and YouTube are currently the only additional “Music Services” on offer from here, but you’ll find over

20 available for download at <http://bit.ly/volumio-plugins>. Drag and drop the zip file to the “Upload Plugin” tab. They’re not officially supported, and can be glitchy, so use them at your own risk.

» The “Miscellaneous” and “System” sections include five plugins that extend support to various hardware add-ons. Of most interest will be the Touch Display Plugin, for those who’ve hooked up their Pi to any touchscreen display (it’s optimized for the seven-inch Raspberry Pi display), plus GPIO Buttons, which enables you to control basic playback options through physical buttons.

» Finally, the “Accessories” section contains an IR Remote Controller plugin for controlling Volumio playback via remote control. It’s configured for JustBoom IR remotes, but also offers profiles for Odroid Remote and Apple remote, too. Don’t forget that you’ll need an IR receiver for your Pi.

» The final plugin should be considered essential: Backup & Restore Data. Once installed, switch to the “Installed Plugins” tab to activate it, then click “Settings,” where you choose what to back up. Your available options are “Queue,” “Playlists,” “Favorites,” “Configuration Data,” and “Album Art.” Click “Backup” and a file called `volumio_data.tgz` will be saved to Volumio’s shared folder.

» Once saved, go into “File Manager → Network → VOLUMIO → Internal Storage,” log on anonymously when prompted, then save `volumio_data.tgz` to a secure location. After restoring Volumio and reinstalling the plugin, be sure to copy this file back to the root directory of “Internal Storage,” then click the “Restore” button to put things back in place.

» You can use the Backup and Restore plugin to do more than simply provide a fail-safe in case of SD card corruption; you can also use it as a crude snapshot tool. About to make a major change to your database? Take a backup, then simply restore it if things don’t go to plan. ⏻

ANOTHER
PI TUTORIAL
NEXT
MONTH

Make Original Music With VCV Rack

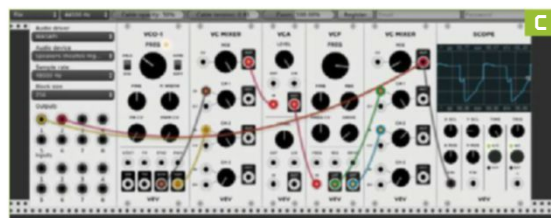
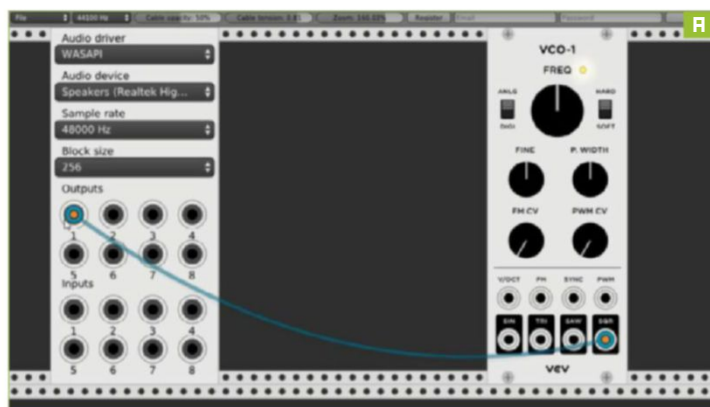
YOU'LL NEED THIS

VCV RACK

Download it from
www.vcvrack.com.

FOR FANS OF BEAUTIFUL ELECTRONIC MUSIC and brain-melting honking noises alike, there's nothing quite like a modular analog synth. The concept behind them is reasonably simple. Start with a signal voltage, generated by an oscillator. Send that voltage through a bunch of modules, each of which subtracts or alters the original waveform, changing its sound. By the time your adulterated voltage reaches the speaker output, you'll (theoretically) have made it into something unique, and the possibilities afforded by modular synthesis—the inputs, outputs, and expandable structure—mean there's an endless variation of possible results.

VCV Rack faithfully emulates proper analog synth equipment, to the extent that some manufacturers of real-world modules have created their own virtual equivalents, so close to the originals that patches—configurations of knobs and switches, which create a particular sound—can be faithfully recreated in Rack from the physical hardware. That said, nothing's ever 100 percent accurate with analog synthesis, and nothing's ever set in stone. You may never find the same sound twice, but the journey to get there is great fun. Just be careful of your speakers, because you never know what noise you're going to make.... —ALEX COX



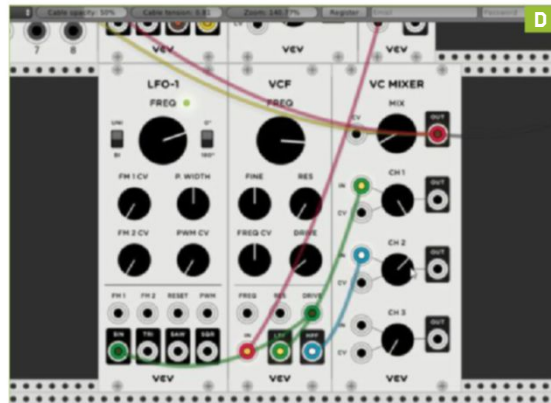
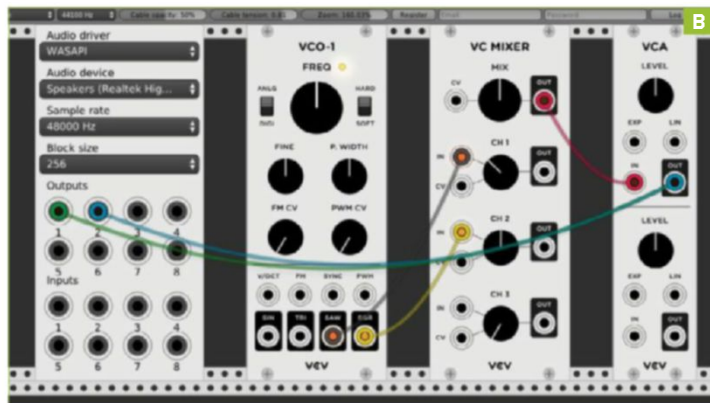
down your system volume, and click and drag from the VCO's "SQR" port to one of the numbered outputs [Image A] on the audio interface. You'll hear a tone from one of your speakers, indicating success; jiggle the "Freq" knob, and the pitch should change.

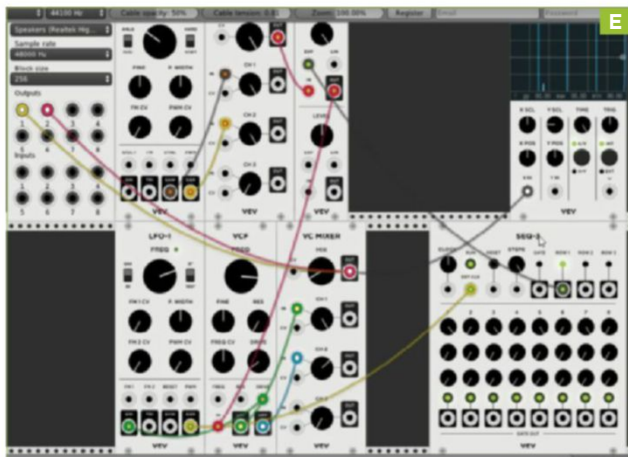
1 MAKE SOME NOISE

With Rack installed and running (you can do it, scout, it's just a couple of clicks), you'll see a slightly worrying empty rack. Let's start filling it up: Right-click in some empty space, and select "Core → Audio Interface" to add an output module. Use the drop-down below "Audio Device" to select your soundcard, then right-click in empty space again to add "Fundamental → VCO-1." This is a voltage-controlled oscillator, essentially a sound generator. Turn

2 ADJUST LEVELS

Pull the wire out to stop the noise, then add some more modules. Begin with some basic quality of life stuff: Add VC Mixer (a simple mixer) and VCA (a voltage-controlled amplifier), both in the "Fundamentals" section. Wire a couple of your VCO outputs into separate channels on the mixer, plug its main, upper output channel to the input on the uppermost section of the VCA, then wire channels one and two of your audio interface to the output





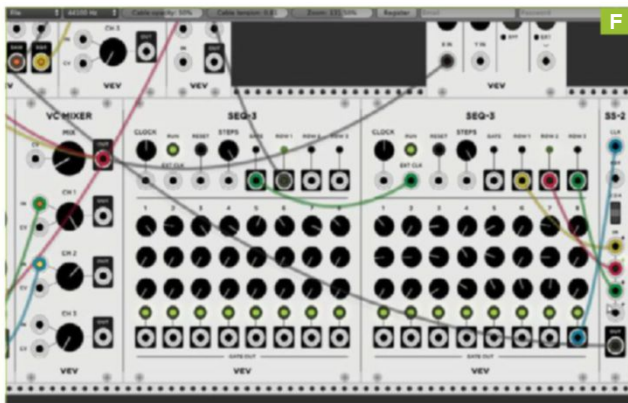
[Image B] of the VCA. Tweaking the knobs on the mixer now enables you to balance the two channels and control the overall volume of the signal.

3 SEE THE SOUND

A scope ("Fundamentals → Scope") is a useful way to get some visual feedback on the signal you're generating. Just add one in, then patch its "X in" socket to the VCA output, tweaking the X scale until the waveform has some decent height. If you're scoping out a square wave, or some combination including one, you'll probably notice some rough edges; a filter, such as "Fundamentals → VCF," can help smooth these. Add one in, place another VCF Mixer next to it, patch the output of your original mixer into the VCF input, then patch the HPF and LPF outputs of the filter into the individual channels of the new mixer. These are the high and low pass filters—essentially smoothing the top and bottom ends of the sound. Wire your new mixer's output to the input of your original VCA [Image C], and tweak the knobs to try out your new sound.

4 ADD DYNAMICS

So far, we've been dealing with a flat tone, but there's no reason to stick with a single tone generator. Let's add another, and make it an LFO-1, or low frequency oscillator. An LFO is rarely used as an instrument in itself, because the majority of its range generates pulses too spaced out to register as sound. Instead, an LFO is used as a trigger for other things. In this case, wire its sine wave output [Image D] to the drive input of the VCF. As the LFO pulses (and you can control its speed with its "Freq" knob), it adds a little periodic crunch to your tone. Try the same output in all the inputs of the VCF to see how it affects the sound, raising the level on the VCA if required.



MIDI INSTRUMENTS

If you have a MIDI keyboard, adding the MIDI to CV module is a must—it enables you to use the notes of keyboard keys (1V/Oct), their velocity, and (if your keyboard supports it) aftertouch, as well as the modulation and pitch wheels to control anything with an input. This could be as simple as wiring the keyboard's 1V/Oct output to the V/Oct input of a VCO, or far more complex—modular synths are all about exploration and experimentation, so it's up to you to find a sound you love.

If you don't have a MIDI keyboard, you can still get a little more interactive with your instruments. Download and install Virtual MIDI Piano Keyboard from <http://vmpk.sourceforge.net>, and MIDI OX and MIDI Yoke from <http://midiox.com>, and set VMKB's output to MIDI Yoke. Add a MIDI to CV module to your synth, set its interface to the appropriate input, wire its 1V/Oct port to something interesting, and use the keys on your computer keyboard to play. Bear in mind that the other MIDI outputs are useless if playing this way, because your virtual keyboard is limited to straight on/off voltages.

5 PULSES ON PULSES

The LFO is giving character to your sound, but a sequencer turns your synth from a drone into a rhythmic machine. Add "Fundamentals → SEQ-3" to your rack, and try not to be too intimidated—it's a fairly simple contraption. Each row output sends a signal, determined by each row of knobs, when the clock (represented by the flashing green light along the bottom) passes them. Wire the "Row 1" output to the "Exp" input of the VCA, then patch the square wave output of your LFO to the external clock input of the sequencer. Now, turn knobs 1, 3, 5, and 7 to full—you'll hear your note pulsing on and off with every beat. Add another sequencer, patch the gate output of the original into the external clock input of the new one to sync them up, then fire its row 1 into the V/Oct input [Image E] of the first VCO-1 instrument we added. You can now use the knobs to control the note played on each beat.

6 MAKING CHOICES

Having multiple rows means we can use sequences longer than just eight beats. Add a Sequential Switch 2, and patch each of the row outputs from your second sequencer to a separate one of its inputs. Wire the final gate output of the sequencer to the switch's clock input, and set the multi position "2:3:4" switch to 3—you should see the green light on it step between each of your three inputs. Now wire the output of the sequential switch to your VCO's V/Oct input [Image F], and enjoy three rows of note selection. ⏻

Go Extreme With Antialiasing

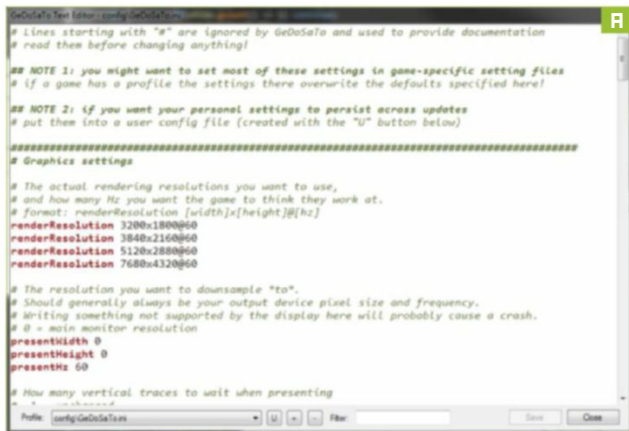
YOU'LL NEED THIS

GEDOSATO

The Rolls-Royce of downsampling tools. Available from <http://blog.metaclassofnail.com>.

NVIDIA INSPECTOR

If you side with Team Green in your PCIe slot, this unofficial app is bristling with tweaks: www.guru3d.com/files-details/nvidia-inspector-download.html.



GET HOLD OF GEDOSATA

You know what they say—if in doubt, downsample. Don't worry about who "they" are, just trust us: They're always saying it. Downsampling is essentially supersampling AA (SSAA) by another name: You render a version of the original image that's much, much bigger—usually x2, x4 or x8 times the size of your native resolution—then you downsample that enormous image so it fits back within the dimensions of your monitor. And you do this by downloading Generic Downsampling Tool, aka GeDoSaTo.

» The advantage of using this program over the AA options in your game's menus is that you get a double-whammy of fidelity: higher image resolution, and smoother edges by virtue of the former. After all, the more pixels there are creating an image, the harder it is to see that step effect when pixels on diagonal lines display an edge. Plus, there's support for really big resolutions, so if you want to go extreme with your AA, this is the program.

 CREATE A CUSTOM SUPERSIZED RESOLUTION

Once GeDoSaTo is up and running, simply hit “Edit Settings” to navigate to the pictured text file [Image A]. Here you’ll see two sets of resolutions: the larger supersampled resolutions above, and your monitor’s native resolution below. Edit these figures to taste—usually going for 1.5 times your native resolution, then two times, then 2.5, then something more ambitious, such as

FORGET FAIR MICROTRANSACTION MODELS and the magic formula for a successful esports game—these are but flash-in-the-pan challenges the games industry faces currently. For a much longer time, 3D designers were stumped by a far more prosaic problem: how to draw curved and diagonal lines without them appearing like a blocky staircase of pixels.

Aliased polygonal edges—or jaggies, as you say in today's parlance, with your low-slung jeans and dangerous new ideas—were a simple fact of 3D graphics for over a decade. It was only in the mid-2000s that antialiasing (AA) became sophisticated enough to smooth out those lines until they appeared realistic, and it still takes a lot of computational power to do so.

In this smoother-edged age, though, new problems have emerged. What if the antialiasing options baked into your game aren't sufficient? And what about playing old games, which offer only perfunctory antialiasing—is that the end of the line for your crusade against the jaggies?

Well, no. There are lots of other options. Here's how to go beyond the graphics menu's limitations, and antialias those edges so much that even Tom Jones would deem them smooth. —**PHIL IWANIUK**

four times, is the best approach. If all works as planned, your game will suddenly recognize these new resolutions, and offer them in the display options menu. We recommend those sizes in particular because rendering images at enormous resolutions, then squishing them back down to size, takes a lot of your GPU's resources, and you'll want a few settings to switch between later on when you're tweaking for optimal performance. The laws of diminishing returns definitely apply here, too, so you may find that 2x downsampling produces a sufficiently smooth image.

3 TURN OFF AA IN-GAME

Now, with GeDoSaTo background, select one

Now, with GeDoSaTo still running in the background, select one of the higher resolutions that have just magically appeared in your game's graphics options menu or launcher. Next, remove any AA effects in the game [Image B], and observe whether downsampling alone has smoothed out the jaggies. There's no point sending two fire trucks out to the same fire, after all. Unless it's a big fire. (We're not totally clear on how the fire brigade works.) If you're getting great antialiasing but a low frame rate, try a smaller resolution. If you're getting the opposite, enlarge the resolution that GeDoSaTo creates.

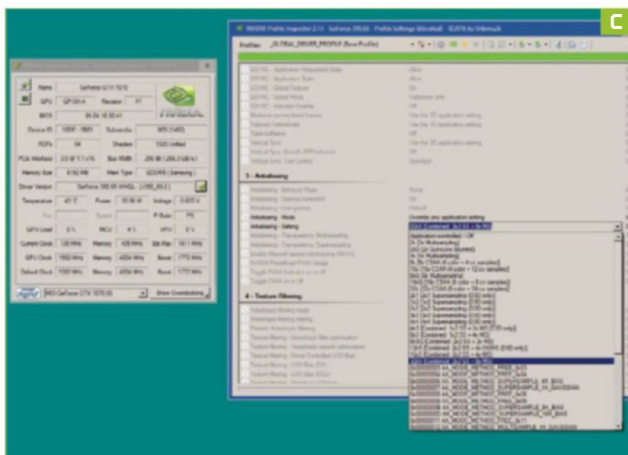
LAYER AA WITH NVIDIA INSPECTOR

4 Here's another approach to your extreme AA solution: layer different techniques. Like downsampling, it's a resource-heavy pursuit, but what





about the word “extreme” implies low power consumption? Pro tip: This is especially handy for older games with weak sauce AA options. Download and install Nvidia Inspector to begin this layering process. Hit that tiny green icon next to the “Driver Version” readout and you’ll see a voluminous options menu pop up. First, head down to the “Antialiasing—Mode” drop-down menu, and select “Override any application setting.” We’ll be using two AA techniques in tandem within Nvidia Inspector, so we don’t need to triple-dip by using the game’s AA, too. Next, navigate to “Antialiasing—Setting,” and choose “32xS [2x2 SS + 8x MS]” [Image C]. That’ll apply two different antialiasing techniques—supersampling and multisampling—taking a total of 32 samples of each frame. While the former creates an artificially higher resolution render of each frame, multisampling AA takes color samples from different points within each pixel, so it can get a better idea of the bigger picture, and smooth lines out accordingly. That is extreme antialiasing, friend.



FINAL TWEAKS

We’re going even deeper here, so first check you’re still getting a playable frame rate with the AA setting we just enabled. Good? Good. Now we’re tackling alpha textures—things such as chain link fences, grass, and foliage—that traditional AA techniques can struggle to smooth. Or, if they’re too aggressive, they can blur them out so much that they become invisible. Back in Nvidia Inspector, you’ll find a setting just below the AA setting from step 4 called “Antialiasing—Transparency Supersampling.” Select “8x Sparse Grid Supersampling” from the drop-down menu. Now you’ll have an AA solution that applies two techniques to every frame, and another one looking out for alpha textures. And best of all, it’s all happening independently of your game’s graphics options menu, so you can apply it to whatever you play [Image D].

GOING TOO FAR

It runs contrary to the spirit of this guide to say so, but there is such a thing as too much antialiasing. And it’s not just defined by the point when your frame rate renders the game unplayable. Over-aggressive AA can blur out images, make entire textures disappear, and give an uncanny valley effect to old games. *Doom* was never intended for smooth edges and high-res textures, so when modern AA techniques are applied, the result is only a passing resemblance to the game you remember. Similarly, in 2D games that feature line drawings heavily in their art style, the once-crisp lines get extra pixels, intended to smooth them out, but which make it look as though someone’s spilled a bottle of water all over your game. So, use AA sparingly in 2D and early 3D titles.

Set Up an Electrum Bitcoin Wallet

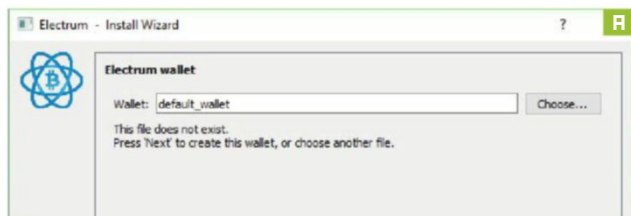
YOU'LL NEED THIS

ELECTRUM

You can get hold of the free software from <https://electrum.org/#download>.

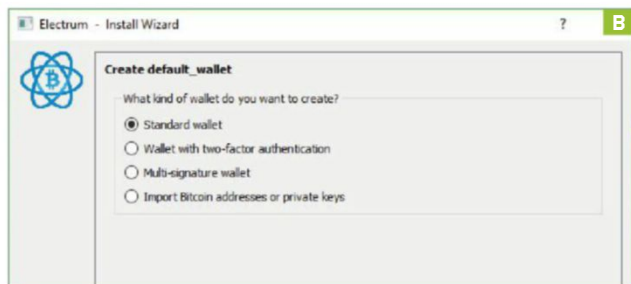
BITCOIN HAS GONE FROM BEING the province of a few bored programmers to a major investment tool. While a single Bitcoin was worth around \$1,000 in January last year, today it's worth well over 10 times that amount. The prevalence of online exchanges such as Coinbase and Bitstamp have also made it easy for even non IT-literate people to cash in on the crypto-craze.

As a virtual currency, Bitcoin is vulnerable to hackers, which is why anyone interested in investing must have a secure software “wallet” to keep their funds safe. Electrum, which has been around since 2011, is a remarkably powerful and free client for Bitcoin. Not only is the software extremely easy to set up, but it uses powerful encryption to keep your wallet files safe. Electrum also supports creation of a special “seed” of 12 random dictionary words, which you can use to restore your Bitcoins if anything happens to your computer. The simple interface, which is written in Python, can be mastered in a few minutes. If you need to check your balance on another machine, Electrum can also load “watching” wallets, which can display your balance but not make payments. —NATE DRAKE

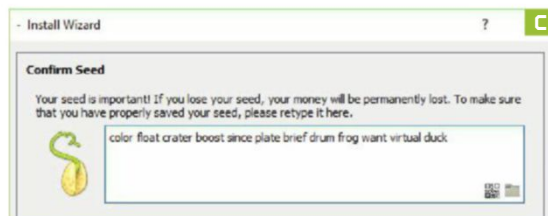


 DOWNLOAD AND INSTALL ELECTRUM

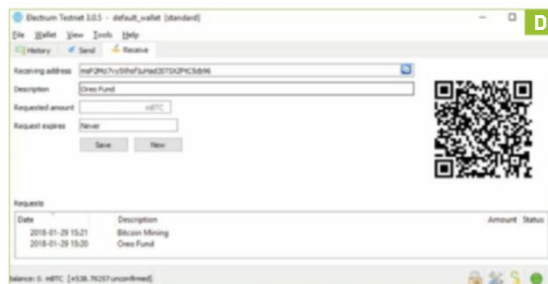
Open your web browser and navigate to <https://electrum.org/#download>. Click “Windows Installer,” then choose to “Run” the file if you’re using Microsoft Edge. The Electrum installer now launches. Click “Next” to choose the default install location in C:\Program Files. Once installation is complete, double-click the Electrum icon on your desktop. Electrum now asks where you wish to store your wallet file. Either click “Next” to save the wallet to the default location (C:\Users\yourusername\AppData\Roaming\Electrum\wallets), or click “Choose” to select a different location. Click “Next” when you’re done [\[Image A\]](#).

 CHOOSE WALLET AND SEED TYPE

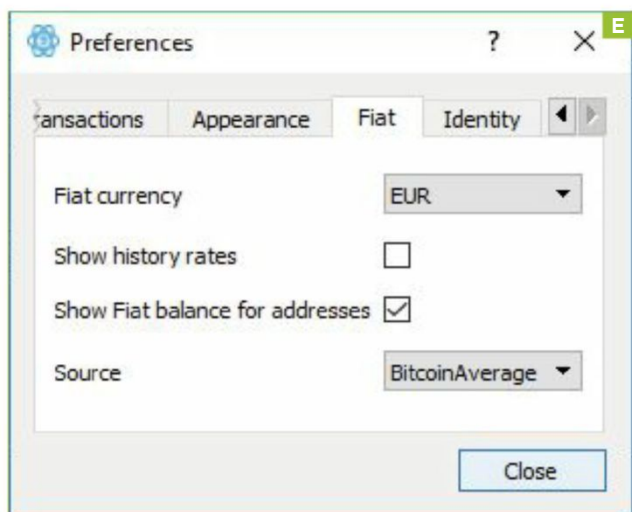
 Electrum supports various types of Bitcoin wallets. If this is your first time using wallet software, leave the “Standard Wallet” option checked here, and click “Next” [\[Image B\]](#). You can create other types of wallets later if you wish. Click “Next” once again to create a new wallet “seed.” Click “Next” again to choose a “standard” seed type. Electrum now displays your wallet generation seed. These 12 words can be used to restore your wallet if anything happens to your computer. Make sure you write these down and keep them in a safe place.

 GENERATE SEED AND ENCRYPT WALLET

3 Once you've written down your wallet seed, click "Next" to continue. Electrum asks you to retype the seed in the following window to be sure you've noted it down correctly [\[Image C\]](#). Click "Next" to continue. You can now set up a password to encrypt the wallet file you created earlier. This is optional, but strongly recommended, because without it, anyone with access to your computer can spend your Bitcoins. Enter the password twice, then click "Next" to continue. Electrum now starts generating your payment addresses.

 **RECEIVE BITCOINS**

4 Once Electrum starts, you'll see your transaction history, which is blank, as you're using a new wallet. Click the "Receive" tab to view your payment address. If you plan to receive funds from more than one source, considering adding a "Description," and click "Save" [Image D]. Click "New" to create as many payment addresses as you like. You can use these to receive funds. If you don't have any Bitcoins, use an online exchange such as Bitstamp (www.bitstamp.net) to buy some.



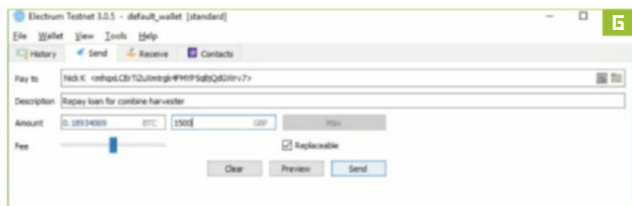
5 A FEW TWEAKS

While you're waiting for your funds to arrive, you can be productive and tweak the Electrum interface. By default, balances are displayed in mBTC (millibitcoin). This can be confusing when requesting amounts in BTC. Select the "Tools" menu, then "Preferences." Click the "Appearance" tab, and choose the "Base Unit" drop-down menu to switch to BTC. While you're here, select the "Fiat" tab, too [Image E]. Select your "Fiat Currency" to see your balance in BTC and Fiat at the bottom-left of the Electrum window.



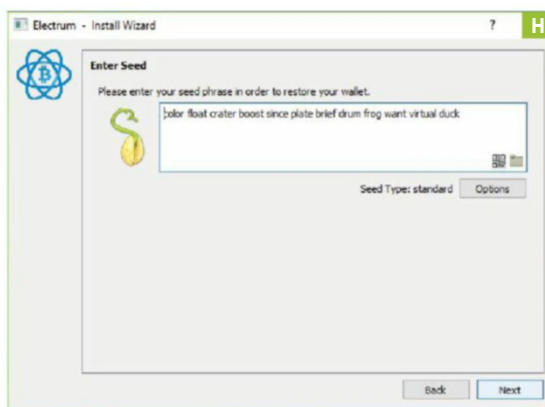
6 ADD CONTACTS

It's virtually impossible to memorize Bitcoin payment addresses. Fortunately, Electrum enables you to store the addresses of those to whom you send funds regularly. To get started, click the "View" menu, and choose "Show Contacts." Click the new "Contacts" tab [Image F], then right-click anywhere to create a "New Contact." Fill in the "Address" and "Name," then click "OK" to save. If you want to send funds to these addresses, just type the first few letters of the recipient's name in the "Pay to" field.



7 SEND BTC

Click the "History" tab to check the status of your received funds. If they've been successfully confirmed, you'll see a green check mark next to the payment date. If you're ready to spend your Bitcoins, select the "Send" tab [Image G]. The fields here are fairly self-explanatory. Enter the recipient payment address in the "Pay To" field. You can also add a payment "Description" if you wish, for your own records. Enter the payment amount either in BTC or your chosen Fiat currency—for example, \$1,500. The fee slider determines the transaction fee you're willing to pay. Generally speaking, the higher this is, the faster your payment is received. Click "Send" when you're sure you want to proceed. Electrum asks



you to confirm the payment amount and mining fee before payment is sent. Click "Yes" to continue.

8 IN CASE OF EMERGENCY

If anything happens to your machine, you can still access your coins on another machine using Electrum. Visit <https://electrum.org/#download> and install Electrum as described in step 1. On the "Create Wallet" screen, click "Next" to choose a standard wallet, as before. When you come to the "Keystore" screen, choose "I already have a seed." Click "Next," then enter the seed you wrote down earlier [Image H]. Click "Next" to restore your wallet. Repeat steps 5 and 6 to display your balance in your chosen currency and restore your contacts. ⏻



WATCHING WALLET

If you're concerned about the safety of your Bitcoins, consider setting up a watching wallet. When run in this mode, Electrum displays your current balance and allows you to receive payments, but you can't spend your coins. This is perfect for installing Electrum on a machine you don't own, such as one in your college or workplace. Begin by clicking on the "Wallet" menu option, then "Information." Follow the instructions in step 1 to install Electrum on a new machine. When you come to the "Keystore" screen, choose "Use public or private keys." Paste the master public key you copied earlier into the box, and click "Next." Electrum alerts you that this is a watching only wallet, which cannot send payments by itself. Electrum also supports "cold storage" mode. This involves setting up two wallets—a watching wallet and an offline wallet on a separate machine. If you need to spend BTC, you can generate and save a transaction file, which can be signed digitally by the offline wallet. Needless to say, this is only for the most paranoid users. You can find further help with this at <http://docs.electrum.org/en/latest/coldstorage.html>.

Create a Pop-Out Photo Effect

YOU'LL NEED THIS

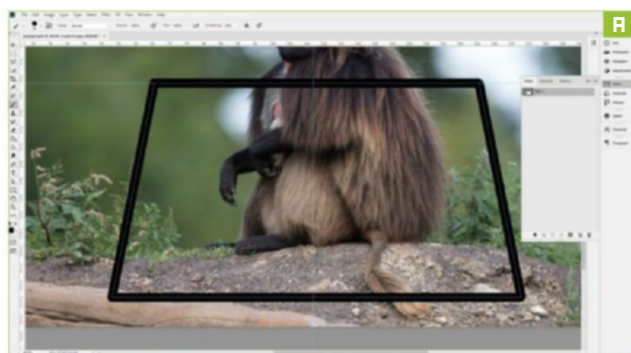
ADOBE PHOTOSHOP,

Subscribe to various packages at www.adobe.com.

WHAT IF YOUR IMAGES COULD RISE UP from their flat prints into three-dimensional solidity? Well, they can't. Sorry. Not without some sort of holographic photo frame that will launch at a ridiculous price, and prove to be as popular as 3D TV.

What you can do, however, is create the illusion of a pop-up image. Doing this involves a couple of layers and a mask in Photoshop, but to make it more interesting, we're going to use a vector mask. Vectors are lines and shapes made of math, rather than pixels, and are usually more at home in Adobe Illustrator or Affinity Designer. Photoshop has a couple of vector tools, including the Pen and polygonal shape tools. They're not used often in photo-retouching, being more for the graphic design crowd, whipping up logos and the like, but have some specific uses that can come in handy.

You're going to need a photo with a strong subject for this project, and it would be helpful if the background isn't too busy, so this is the perfect opportunity to hone your large-aperture background destruction skills. —IAN EVENEDEN



1 GUIDING LIGHT

Once you've chosen your photo, decide how much of it you want to have popping out of the frame. Drag a horizontal guide down from the top ruler ("View → Rulers" if they're hidden), and leave it across your image at the point you want the top of your frame to be. Guides are purely for your reference, and don't print. Drag another, vertical, guide across, and place it where you want the horizontal center of your frame to be, creating a cross.

2 CHOOSE YOUR PATH

Double-click your Background layer to rename it, then duplicate it. Make sure you rename the layers, so you can recognize them later. Select the one at the top of the stack, and select the Rectangle tool from the toolbar. This tool does nothing

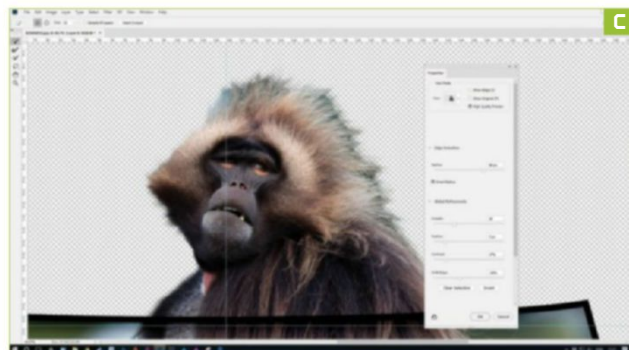
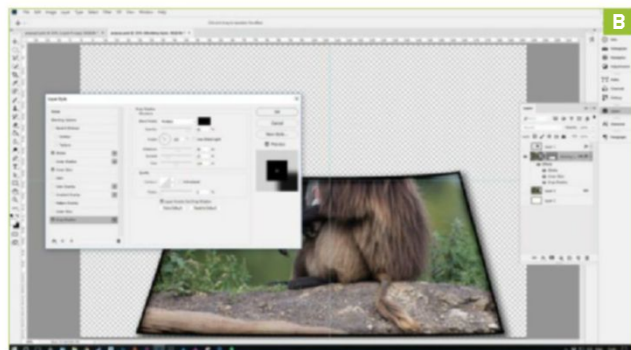
but draw rectangles, but it draws them as vector shapes. For our purposes, we want a rectangular path on the layer we're working on, rather than a free-floating shape, so choose "Path" from the "Options" menu at the top of the interface, rather than "Shape."

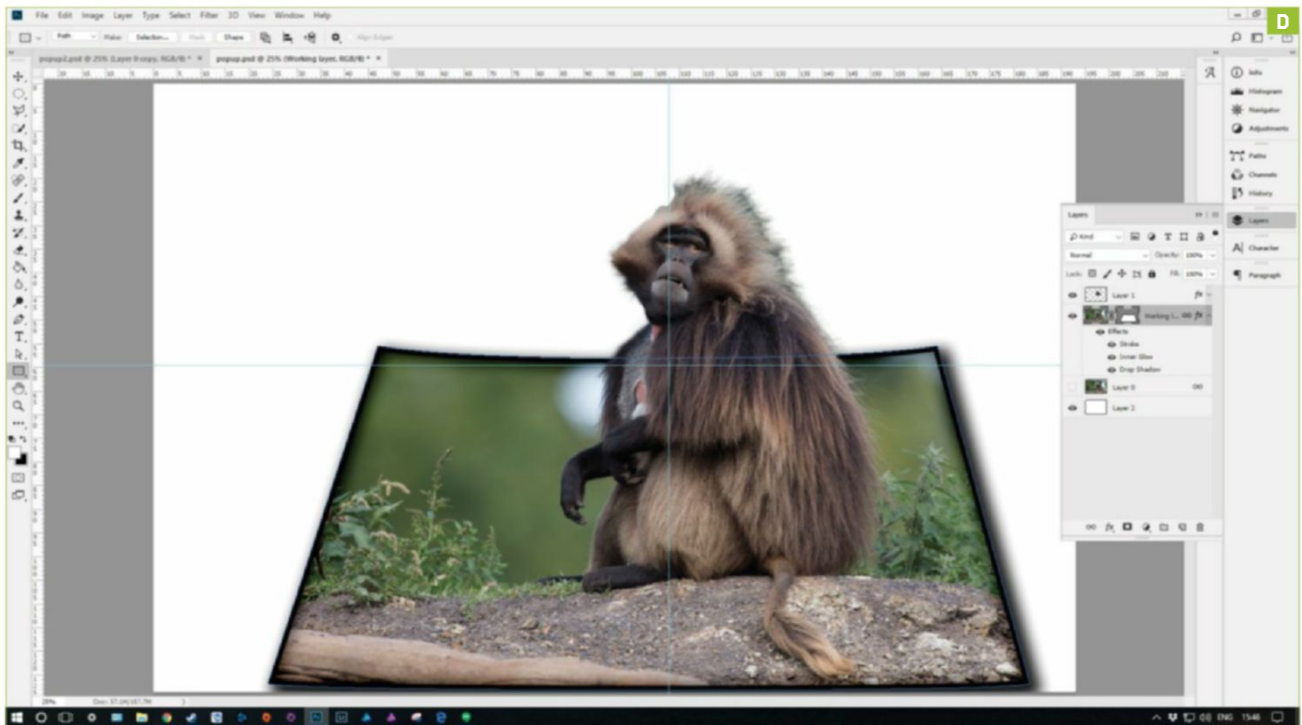
3 IN THE FRAME

Draw a rectangle on the bottom half of your image, using the guides you placed earlier to help you. This rectangle will become the frame your cut-out image pops out of, so make sure the top is in the right place—the shoulders if you just want a head popping out, or lower if you want more of the body exposed. Open the "Paths" palette, and you'll see your new path in there as "Work Path"—double-click it to rename it. To make your path into the frame, we need to warp it a bit to apply a pseudo-3D effect. With your path selected, choose "Edit → Transform Path → Perspective," and drag the top-left corner of your rectangle to the right. The right-hand corner moves in by the same amount automatically [Image A]. When it's 3D enough for you, click "OK," and dismiss the warning about converting your shape to a path—a path is what we want.

4 DIFFERENT STROKES

Next, we need to "Stroke" it—that is, paint some color along the path's otherwise invisible vectors. Select your path in the Paths palette, and choose the Paintbrush tool from the toolbar. Choose a brush that's





the right size for the thickness of frame you have in mind, and pick a color that suits, too. We've gone for black. On the Paths palette, click the "Stroke" button at the bottom, with the path selected, and the correct layer in the Layers palette chosen, too—the paintbrush stroke you're applying will appear on this layer. Remember, you can always hit Ctrl-Z if you don't like the effect, and then change your brush or color.

S IN THE SHADOWS

That frame is now permanently painted on the layer. Head up to the "Layer" menu, and choose "Vector Mask → Reveal All." This should change... nothing. This is because the duplicate layer you made earlier is showing through from underneath, but hide that by clicking its eye icon, and you'll see that everything

SHAPES AND LAYERS

When you draw a vector shape in Photoshop, what you're creating is a fill layer linked to a vector mask—this is why a shape seems to float freely from other layers, because it's a layer in its own right. When you've created a shape, it remains editable as long as you don't choose to rasterize it. You can use the Direct Selection tool to modify it, clicking and dragging on the square points that mark its corners and the halfway points of its vertices. You can apply a Layer Style to a shape, just as we did with the frame for our pop-up photo, and you can fill it with a pattern or gradient using "Gradient Overlay" in the "Layer Styles" window. The Custom Shape tool, which folds out from the Rectangle tool, means you don't need to be constrained by the Ellipse, Rectangle, Line, or Polygon tools—you can go completely freeform. Lines with arrowheads on them are also created as Shapes—draw a line, and you'll find an "Arrowheads" drop-down on the "Options" bar at the top of the interface. Useful if you're drawing diagrams for use in a presentation.

outside your frame disappears. Now is a good time to add some effects [Image B], such as a drop shadow below your frame, using the Layer Styles palette you can get to by right-clicking the layer, and choosing "Blending Options." Experiment with various glows and shadows until you get something that looks right. You'll have to increase the "Distance" slider on your shadow, because by default it's tucked right under the original layer, and hard to see.

6 HAIRY SITUATION

The next job is to select the bit you want to pop up out of your frame. Hide all layers except the untouched duplicate you made back at the beginning, and make your selection on this. We made life difficult for ourselves by choosing a photo of an extremely hairy creature—a full head of hair is a rarity in the *Maximum PC* office, so it's always good to see what you're missing. We began with the Pen tool, dragging a rough path around the edges of the baboon, before loading the path we'd drawn as a selection using the button at the bottom of the Paths palette, and opening "Select and Mask" [Image C] from the "Select" menu to add some finesse. We ended up with a very soft selection that still includes a little bit of background, and will need to be worked on further. It's enough, however, to create the effect we're looking for.

7 FINISHING TOUCHES

From the "Layers" menu, select "New → Via Copy." This creates a new layer containing only the contents of your selection. Move this to the top of the layers stack, and hide the original. Un-hide the layer containing your frame, and your final composition is revealed [Image D]. Add a white background layer if you want, as this often looks better than the checkerboard of a transparent background, and save as a PSD to preserve layers. If you export directly as a JPEG, a white background appears automatically as your layers are discarded. ⏻



LEVEL OF DIFFICULTY: **MEDIUM**

WHEN LIFE GIVES YOU LEMONS...

SPEND WAY TOO MUCH MONEY on a motherboard and call it a day? That's our philosophy for this build. Damn, that mobo is pricey, but not without good reason. We wanted to go with Coffee Lake for this rig on a number of grounds. Six cores and 12 threads is enough to take care of any application we can throw at it. Whether it's rendering, streaming, gaming, or two of those at once, this machine is more than capable of outputting a significant amount of content, quickly and efficiently. On top of that, Coffee Lake has proved that Intel still dominates the field when it comes to single-core performance, and because games typically rely more on clock speed than on multiple cores, Intel is also still the chip of choice for most AAA titles.

Couple that with a motherboard that goes above and beyond when it comes to connectivity and quality audio, and we're on to a winning combo. The Godlike supports up to five M.2 PCIe SSDs, a sixth via U.2, plus six SATA drives for storage alone. On top of that, it packs in four separate PCIe x16 slots, triple Gigabit Ethernet, and wireless A/C. MSI has crammed practically everything on to this lumpy chunk of PCB, and, to be frank, it looks baller to boot.

We decided to go with some serious storage for this build, with less emphasis on solid state for once—sorta. We're talking a 512GB Intel 760p PCIe SSD for the boot drive, with a stellar 12TB of spinning platters from Seagate's BarraCuda Pro HDD. For our GPU powerhouse, we've gone with our ever faithful PNY GeForce GTX 1080 Ti—a no-frills card, and that's all there is to it. Job done.

INGREDIENTS

PART		STREET PRICE
Case	Cooler Master Cosmos C700P	\$291
Motherboard	MSI Z370 Godlike Gaming E-ATX	\$600
CPU	Intel Core i7-8700K	\$340
Memory	32GB (4x 8GB) Corsair Dominator Platinum 3,200MT/s	\$500
GPU	PNY GeForce GTX 1080 Ti XLR8 Gaming OC	\$940
PSU	Cooler Master V650 80+ Gold	\$95
Storage 1	512GB Intel 760p M.2 PCIe SSD	\$199
Storage 2	12TB Seagate BarraCuda Pro 12TB 7,200rpm	\$450
Cooling	Cooler Master MasterLiquid ML240L RGB	\$70
OS	Windows 10 Home	\$100
Total		\$3,585

1

MOTHERBOARD INSTALLATION

THE GODLIKE GAMING is a monstrous mobo of Coffee Lake destruction. And it fits in the Cosmos C700P like a dream. It's big, seriously big—E-ATX to be precise, which is fairly impressive for a mainstream platform, but the audio componentry, combined with the extensive overclocking hardware and ridiculously over-the-top I/O, makes it more than worthwhile. Word of note: The Cosmos C700P doesn't have all the stand-offs installed for ATX by default, so you do have to pop those in yourself, using Cooler Master's included stand-off mounting tool.



2

COOLING CHOICES

WE HAD A LONG CHAT with Cooler Master about what kind of cooling we should use for this build, and it was a toss-up between these two little beauties: On the left is the ML240L RGB all-in-one; the one on the right is the Master Air MA610P with RGB controller (think of it as a slightly more premium variant of the Hyper 212 Evo). Both are swanky, but with concerns over the Core i7-8700K being perhaps a little too hot-headed when clocked any higher than stock, we opted for the AIO. That said, another air-cooled build is definitely on the cards soon, because they look so good when done right.



3

BACKPLATE PERFORMANCE

AMAZINGLY, COOLER MASTER hasn't fallen into Asetek's patent trap, and has its own bespoke mounting solution. It's fairly intuitive, although you do need to use the instruction manual to get a fix on which bolt goes where. It's also worth noting that you'll need a third hand, to hold everything down while you try to secure it in place on the other side of the board.



4

FAN DOMINATION

ONE OF THE BIGGEST SURPRISES in the Cosmos C700P was this little beauty, carefully hidden away under the SSD mount at the back. It's a beastly chunk of PCB, capable of powering up to 10 PWM fans and three RGB strips. It's controlled by a switch on top of the chassis, or via a link up to your motherboard. Two things to note: If you want to install an SSD here as well, don't panic, because there are pre-threaded holes going through to the other side, so you can still secure it down, no problem. Secondly, don't forget to plug in the SATA power that's sneakily hidden in the bottom of this monstrous thing.



5

ALL THE STORAGE

FOR THIS BUILD, WE'VE OPTED to go with a single 12TB BarraCuda Pro drive from Seagate. It may not have the same prestigious performance as its Ironwolf twin we've reviewed this issue (pg. 87), but it's still no slouch, and more than enough storage for any form of media we want to throw its way. Ideally, we'd have preferred to perhaps have four 3TB drives instead in RAID 1, and do away with the additional 6TB for the sake of redundancy, but Seagate was cruel, and sent us this instead.



6

PSU REQUIREMENTS

YEP, FOR THE SHARP-EYED AMONG YOU, you can possibly make out the 650W power supply handling all that heat-inducing hardware. Amazingly, even under full load, we don't expect to see this machine hit anything more than 520W, giving us well over 130W of headroom to play with. It's likely we won't be tweaking this build much, so this small saving is more than adequate. Incredibly, even with 4x 8GB sticks of DDR4, a GTX 1080 Ti, and Intel's most power-hungry consumer processor yet, on a 650W PSU, we're still stuck merrily at 80 percent of overall capacity, which is the exact sweet spot needed for maximum efficiency.





1 32GB of Dominator Platinum @ 3,200MT/s is probably a touch overkill for this build, but there's no denying it looks awesome.

2 PNY's GeForce GTX 1080 Ti has only very subtle red lighting in the actual fan blades, meaning a very clean-looking silver GeForce logo to complement the build.

3 These two panels can be easily removed with just a couple of Phillips head screws, to allow for easy installation of 3.5-inch hard drives and the PSU.

4 If pricing was less of an issue, a second GTX 1080 Ti and a sleek SLI bridge would have made this machine killer—although a bigger PSU would then have been a must.

COSMIC ENTITY

NOW THAT'S ALL OVER, how was building in the Cosmos's successor? Pretty sweet. It's one of the few cases that you can strip down almost completely to its bare bones. There was very little left of it on our usual skeleton run, and it made building in the colossus far easier than we first thought. The ATX stand-offs requiring pre-installation did catch us a little off-guard—after all, who in their right mind would plop an ITX motherboard in a full tower? But that aside, we had very little trouble with it.

One thing we would add is that it's quite tricky to tinker with after you've built it. Removing those front side PSU and hard drive bay covers makes system installation easy, but trying to sort things out after they were reinstalled was a bit of a nightmare. In short, we couldn't quite identify how that RGB fan controller was powered at first, deducing it to be some sort of sorcery and internal headered USB magic. It was only under further inspection, once the system was complete, that we noticed the not-so-obvious SATA power located at the bottom of the fan controller. At which point, we immediately threw an additional SATA power cable into the PSU, which was frustrating to say the least. Still, we finally got it plugged in, with those LED strips firing away in a stunning shade of purple. It's a shame that you guys don't get to see the fun we have at the photo studio. Most of the final shots (especially with LEDs) are

comprised of two images: one that's well lit, and an LED shot taken in pitch black. The two shots are then skillfully stitched together so everything is lit to the degree that our eyes typically see. In complete darkness, those light bars really do shine, and it's beautiful.

Light bars aside, performance was a given. But it would be—the Core i7-8700K pumping away at this rig's heart is a masterfully crafted single-core killing machine. Multiply that by 12, and you're looking at some very tasty rendering performance. There's little that this

system can't do, especially in game. There are a few things we'd like to tweak, though, to make that price point more bearable. For instance, a bigger PSU and a braided cable kit would be stellar. Couple that with some additional off-the-shelf cooling and internal lighting, and it would really round out the build. Also, some method of reducing that GPU sag would be good. All in all, our Cosmos was a joy to build in, and stood up to its predecessor's legacy. Whether it will also stand the test of time, though, we'll have to wait and see. ⚡

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	1,390 [-36%]
CrystalDisk QD32 Sequential Read (MB/s)	3,136	3,065 [-2%]
CrystalDisk QD32 Sequential Write (MB/s)	2,126	1,580 [-26%]
Rise of the Tomb Raider (Avg fps)	68	64 [-6%]
Total War: Warhammer II (Avg fps)	42	42 [0%]
Tom Clancy's Ghost Recon Wildlands (Avg fps)	38	38 [0%]
3DMark: Fire Strike (Index)	6,988	6,939 [-1%]

Our zero-point consists of an Intel Core i7-7900X, 32GB G.Skill Ripjaws V Series DDR4 @ 3,000, MSI GeForce GTX 1080 Ti Gaming X, and a 512GB Samsung 960 Pro PCIe SSD. All tests performed at 4K at the highest graphical profile.

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REVIEWS

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The Titan Pro's size matches its name, but so does the noise it makes.

MSI GT75VR 7RF Titan Pro

Big, loud, and very pricey

WHAT HAPPENS when you put the equivalent of a complete desktop into a notebook chassis? How about if you include a bit of the desk? MSI's GT75VR 7RF Titan Pro answers that question with an everything-including-the-kitchen-sink attitude.

For starters, it's gigantic, even by desktop-replacement standards. We've tested some large laptops over the years, but at more than 2.2 inches thick, the Titan Pro is absolutely massive. A good portion of that is due to the cooling solution, with more than 10 heat pipes, dual exhausts, and twin super-large, 29-blade fans (more on those later). Adding to the heft is the SteelSeries mechanical keyboard, and while its removable keycaps are still chiclet in style, they have a satisfying click that feels great to type and game on.

The Titan's insides are quite impressive as well. Computing duties are handled by an Intel Core i7-7820HK processor paired with a whopping 64GB of DDR4-2400 RAM. Storage is capacious, too: 1TB of fast storage, courtesy of two 512GB M.2 PCIe SSDs in RAID 0, paired with additional storage via a 1TB 7,200rpm HDD. The former is definitely impressive, offering read/write speeds of 3,391/2,947MB/s in CrystalDisk QD32 sequential. It also scored excellently in PCMark 10 Express, with 4,395, one of the highest scores we've seen in a laptop form factor. Though, again, this is really much more

of a desktop replacement than an actually portable laptop.

The GT75VR is available in several SKUs, dependent on how you like to game. For the display, you can choose between a 4K IPS panel or a higher refresh rate 120Hz 1080p screen that's unfortunately a TN panel—though both offer G-Sync. The unit we tested featured the former, and while colors looked great, it left us wanting more. We generally try to avoid 4K screens on gaming laptops, as the GPU power required to maintain 60fps in the latest games is difficult even for top-end desktops. The GT75VR we tested was outfitted with a single GeForce GTX 1080, which is more than capable at 1080p but can struggle at 4K. (There are also single and double GTX 1070 SKUs available.)

NUMBER CRUNCH TIME

Let's look at some numbers. The Titan Pro's GTX 1080 performed well in our 1080p gaming tests, scoring 76fps in *Total War: Warhammer II*'s battle benchmark, and 61fps in the super-demanding *Ghost Recon: Wildlands*. It was able to handle the slightly older *Rise of the Tomb Raider* even more easily, scoring an average of 110fps across the game's three-part benchmark.

However, our machine had a 4K screen, so it made sense to test at that resolution, too. At that more demanding resolution, the single GTX 1080 struggled. *Rise of the Tomb Raider*, the easiest of the gaming

tests, returned scores of 53fps in the Mountain Pass, 44fps in Syria, and 43fps in the Geothermal Valley, for an average of 47fps—not great. Meanwhile, the more demanding *TW: Warhammer II* and *Ghost Recon: Wildlands* proved even more difficult, with 30 and 29fps, respectively.

In other words, the single GTX 1080 couldn't maintain 60fps at 4K in any of the games we tested, and while you can drop to 1080p, you're then saddled with the 4K screen's more limited 60Hz refresh rate. And if you opt for the 1080p 120Hz panel option that's available, you're stuck with a TN screen. For a machine with these sort of internals, we would have much preferred a high refresh rate 1440p IPS screen—especially at this price point.

One other thing to note is the fans. The GT75VR boasts a robust cooling system, featuring MSI's "cooler boost" technology. It certainly succeeded at keeping things cool, but it was incredibly loud doing so. Even after tweaking some settings, the fans made a ton of noise whenever they spun up even a little bit. For all the hubbub over impressive cooling tech—not to mention the massive chassis—we hoped that things would stay quiet during regular gameplay, cranking up the volume only when pushed to the absolute limit. —BO MOORE



MSI GT75VR 7RF Titan Pro

■ **TITANIC** Mechanical keyboard; great cooling; superb speakers.

■ **ICEBERG** Expensive; gigantic; loud.

\$4,200, www.msi.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	743	771 [4%]
Cinebench R15 Single (Index)	155	164 [6%]
CrystalDisk QD32 Sequential Read (MB/s)	563	3,391 [502%]
CrystalDisk QD32 Sequential Write (MB/s)	133	2,947 [2,116%]
PCMark 10 Express (Index)	3,852	4,395 [14%]
Rise of the Tomb Raider (fps)	13,202	15,360 [16%]
Total War: Warhammer II (fps)	99	110 [11%]
Ghost Recon: Wildlands (fps)	62	76 [23%]
3DMark Fire Strike (Index)	48	61 [27%]

Our laptop zero-point is the Asus GL502VS-DS71, with an Intel Core i7-7700HQ, a 8GB GTX 1070, and 16GB of DDR4-2400. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

Processor	Intel Core i7-7820HK @ 2.9GHz
Graphics	Nvidia GeForce GTX 1080
RAM	64GB DDR4-2400
Screen	17.3-inch 4K IPS G-Sync
Primary Storage	1TB (2x 512GB) M.2 PCIe SSD RAID 0
Keyboard	SteelSeries mechanical keyboard with per-key RGB lighting
Battery	75Whr eight-cell Li-Ion
PSU	330W
Total Weight	9.92lb

Nvidia Titan V

How to build your own Skynet

LOOKING AT THE CALENDAR on the wall, we realize that Nvidia's Pascal debuted about two years ago now. It used to be that we could expect some massive changes in that time, but today's Titan Xp is built off that same original GP100 that first appeared way back in the Tesla P100. That was an insane part, built for machine learning, and the GP100 never showed up in a consumer product (unless you count the \$7,499 Quattro GP100). Nvidia has decided to try a new approach with its GV100 core—which sits at the heart of the Tesla V100 and goes after a similar market as the P100—and has released the prosumer and machine learning focused Titan V.

Nvidia's Titan series of graphics cards has always been more about status than practicality, and waiting a few months could usually net you nearly the same level of performance for about half the price. This time, rumors are swirling about Volta, suggesting we might not even see GeForce variations, and instead will get Ampere GPUs later this year. That's not really a problem, assuming Ampere is to the GV100 what the GP104 was to the GP100. The problem is that GV100, for all

its performance, has a lot of extra design elements that simply aren't ideal for graphics workloads.

Take the 64 CUDA cores per SM (streaming multiprocessor), with 32 FP64 (floating point) cores, and the ability to do twice as many packed math (FP16) operations as FP32 ops. FP64 isn't something games use or even need, though there may be some algorithms where the packed math support proves beneficial. Even more than this, the presence of the new Tensor cores—eight per SM—takes a lot of space, and these cores are special purpose constructs designed to accelerate FP16 machine learning operations. Toss in HBM2, and you have a very large, very expensive core that's not a great fit for consumer workloads.

That's why Nvidia is marketing the Titan V not at extreme gaming, but at machine learning researchers. Without such a product, the only way to get access to Nvidia's Tensor cores would be through DGX-1 servers, or a few cloud computing options. But the DGX-1 is back-ordered, and even if it wasn't, it runs at \$149,000 per server, including eight Tesla V100 cards. Three grand for a Titan V that includes all the core features is a bargain by comparison, and opens the door for university researchers to come to grips with the technology before moving to larger supercomputing installations.

In our review of the Falcon Northwest Tiki last issue, we noted that the Titan V is a potent solution for both machine learning and graphics work, easily claiming top honors in our gaming test suite. But how does the Titan V perform if we throw caution to the wind and overclock it? We managed to push the core clocks up by 150MHz and the

HBM2 by 125MHz. Combined with maxing out the power limit—and the fan speed—performance improves by a substantial 25–30 percent, but the GPU starts hitting thermal and power limits, meaning there's potentially even more headroom available.

Even redlining a GTX 1080 Ti or Titan Xp, you're not coming anywhere near the overclocked Titan V. However, it is worth noting that the Titan V doesn't include SLI connectors, so while running multiple cards for machine learning purposes is possible, you're not going to be able to improve gaming performance beyond what you get with a single card.

Regardless of whether Volta GPUs show up in GeForce cards in the coming months, some variation on the gaming aspects of the Titan V will almost certainly appear. Give us 12GB GDDR6 and the same 5,120 FP32 CUDA cores (or more) but in a smaller, more affordable package, and you can call it Volta, Ampere, Turing, or Marie. Whatever the name, it will be awesome, and Dream Machine 2018 is already on the drawing board. As for the Titan V, unless you are after a machine learning tool, save your money and wait for the next generation non-Titan cards to arrive. —JARRED WALTON



Nvidia Titan V

■ ALESSANDRO'S BATTERY

Fastest GPU around; overclockable; machine learning.

■ **FLAT BATTERY** Exorbitant pricing; power/thermal limits; wait for next-gen GeForce.

\$2,999, www.nvidia.com

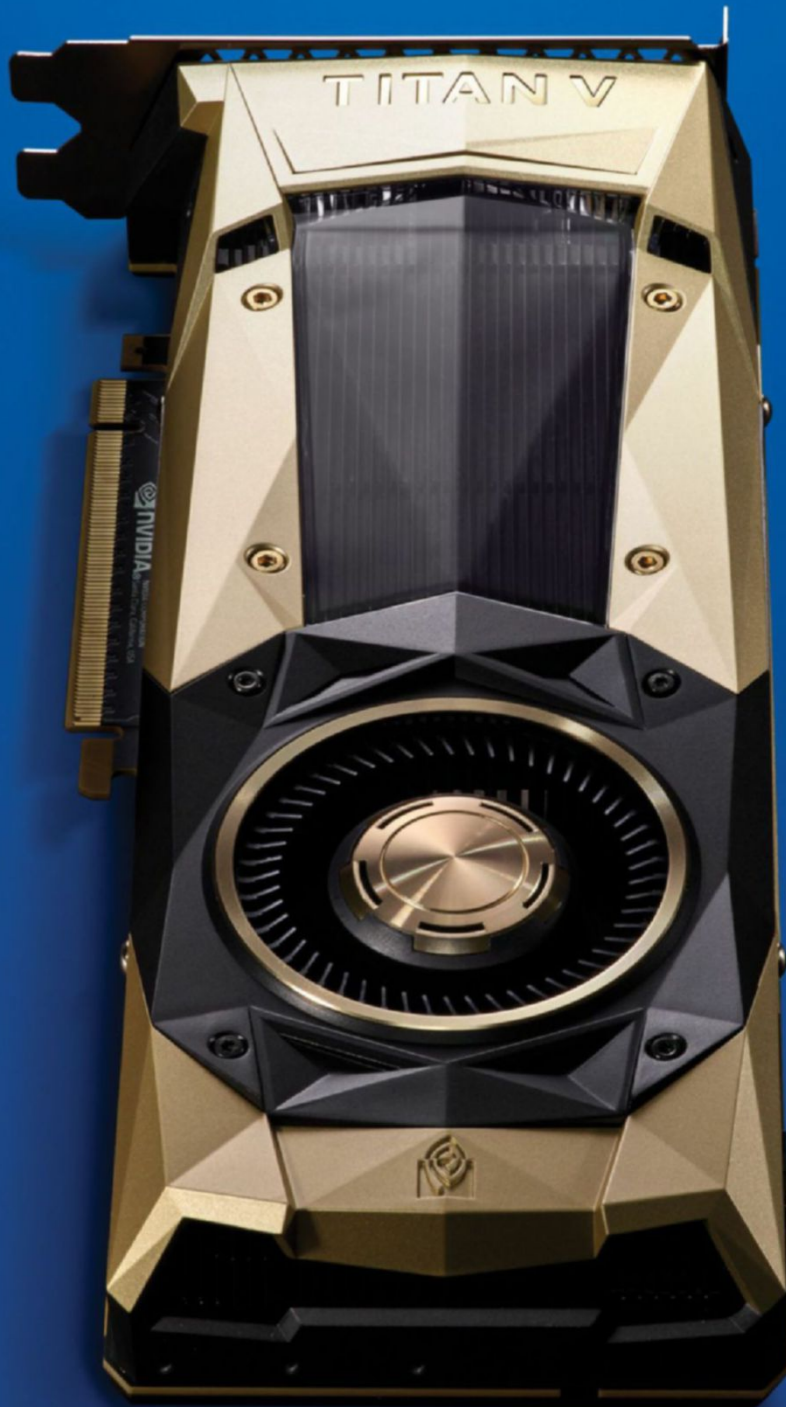
BENCHMARKS

	Nvidia Titan V	Nvidia GeForce GTX 1080 Ti
Deus Ex: Mankind Divided (Avg fps)	87/48	80/43
Far Cry Primal (Avg fps)	110/64	97/57
Ghost Recon Wildlands (Avg fps)	58/37	58/36
Middle-Earth: Shadow of War (Avg fps)	94/56	93/53
Total War: Warhammer 2 (Avg fps)	66/35	57/32
The Witcher 3 (Avg fps)	116/73	94/57
22-Game Average fps	109/70	101/62

Best scores are in bold. Bespoke tests specifically for the Titan V, tests performed at 1440p and 4K. Our test bed consists of an Intel Core i7-8700K, 16GB of Corsair DDR4 @ 2400, an Asus Maximus IX Hero, and a 500GB Samsung 850 Evo. All games tested at their highest graphical profile.

SPECIFICATIONS

GPU	Volta
Lithography	12nm FinFET
Transistor Count	21.1 billion
CUDA Cores	5,120
Texture Units	320
ROPs	96
Core/Boost Clock	1,200/1,455MHz
Memory Capacity & Type	12GB HBM2
Memory Speed	652.8GB/s
Memory Bus	3,052-bit
TDP	250W
Connectors	3x DisplayPort, 1x HDMI



The Titan V sports a familiar design and is fittingly clad in gold.

AMD Ryzen 5 2400G

Integrated graphics get an upgrade

RYZEN'S IMPACT on the CPU market has been profound, but all the chips so far have been straight CPU affairs and lack integrated graphics. The Ryzen 5 2400G changes that—significantly. Until now, integrated graphics haven't been anything to get excited about—Intel's HD graphics have been improving, but they're nowhere near discrete offerings. The Vega 11 GPU beating inside this chip closes that gap—it actually delivers decent 3D performance.

The CPU side of the equation is ostensibly comparable to the Ryzen 5 1400 that it's set to replace, with a quad-core, eight-thread architecture, albeit with a faster base clock of 3.6GHz and a turbo of 3.9GHz (up from 3.2GHz and 3.6GHz respectively). This increase is possible thanks to the fact that the new "Raven Ridge" APUs use a single core complex containing all four cores, as opposed to a pair of dual-core complexes, as in the Ryzen 5 1400. This means there is less cache on offer—the Ryzen 5 1400 has 8MB of L3 cache, while there's only 4MB here. Latencies are improved for the single core complex design, though, which means you shouldn't spot the drop in cache.

As hinted at by its name, the Radeon Vega 11 graphics subsystem boasts 11 compute units, equating to 704 stream processors, 44 texture mapping units, and 16 ROPs (render outputs). This is tiny compared to high-end graphics cards (the Vega 56 has 56 compute units, for instance, which equates to 3,854 stream processors), but impressive for an integrated offering. This

graphics core operates at 1,250MHz, which isn't exactly hanging around. It's not going to replace graphics cards for high-end gaming, but it's more than we're used to.

How does the Ryzen 5 2400G perform? It's good. Nothing too far outside our expectations, but not disastrous. The eight threads mean it outperforms Intel's similarly priced Core i3-8350K in Cinebench's multiprocessor test, and it's faster in Fry Render, too. Intel's single-core performance evens things out, though, and X265 has the chips neck and neck.

NOVEL GRAPHICS

One thing to note with our benchmarks is that our main processor tests use a GeForce GTX 1080. So the benchmarks aren't any indication of the main selling point of this chip—the integrated graphics. The inclusion of integrated graphics does impact the capabilities of the chip when it comes to discrete graphics—the PCIe bus operates at x8 as opposed to the x16 you'll find on non-APU Ryzen chips. This results in a lower score in *Far Cry Primal* (71fps as opposed to the 77fps norm), and as you push your graphics card harder, we'd expect to see a bigger disparity.

With integrated we got most games to hit smooth frame rates at 1080p with some tweaking. By doing so we managed to get 30fps in *Rise of the Tomb Raider*, 24fps in *Shadows of War*, and roughly the same in *Total War: Attila*. This sometimes took some harsh pummeling of the settings,



but at least it's possible where it often isn't with the last-gen solutions. *Overwatch*, that budding newbie on the esports scene, highlights what's possible when you're dealing with a well-optimized engine—it managed a consistently smooth 60fps at medium settings at 1080p. Not bad at all.

Overall, we're impressed with the Ryzen 5 2400G. You'll still want a discrete card if you're at all interested in tinkering with high settings and anything above HD resolutions, but for a lot of mainstream gaming, it handles itself well. If you're looking to build an entry-level gaming rig on a tight budget, this should be at the top of your list. —ALAN DEXTER

VERDICT
9

AMD Ryzen 5 2400G

■ **ALPHA LYRAE** Surprisingly powerful GPU; fast core clocks; great value for money.

■ **BETA SCORPII** Limited max PCIe lanes; needs speedy RAM.

\$169, www.amd.com

BENCHMARKS

	AMD Ryzen 5 2400G	Intel Core i3-8350K
X265 Benchmark (fps)	15.92	15.92
Cinebench R15 Single (Index)	133	169
Cinebench R15 Multi (Index)	837	666
Fry Render (Seconds)	311	352
AIDA64 Memory Latency (ns)	67	58
Total War: Attila (fps)	36	40
Far Cry Primal (fps)	71	77
3DMark: Fire Strike (Index)	14,483	15,725
Power Draw Idle (Watts)	39	50
Power Draw Load (Watts)	109	117

Best scores are in bold. Our test bed consists of a MSI B350I Pro AC (AMD) or an Asus Maximus X Hero (Intel), 16GB (2x 8GB) of Corsair Dominator Platinum DDR4, an Nvidia GeForce GTX 1080, and a Samsung 850 Evo 500GB SSD. All games were tested at 1440p on the highest graphical profile.

SPECIFICATIONS

Base Clock	3.6GHz
Turbo Clock	3.9GHz
Cores/Threads	4/8
Lithography	14nm
Cache	4MB L3 [2MB L2]
Memory Support	DDR4-2933
Memory Channels	2
Max PCIe Lanes	8+4
Graphics	Radeon Vega 11
Graphics Clock	1,250MHz
TDP	65W

Intel Core i3-8100

Proof that processors are still advancing at an impressive rate

THERE WERE LOTS OF REASONS to get excited about Intel's eighth-generation (Coffee Lake) Core processors, but for this reviewer, it was the promise of this particular chip that produced the excitement. The reason is straightforward enough—it potentially offers the best bang for your buck of any of the new chips. The good news (if slightly premature in terms of this review), is that it delivers on that potential and, in fact, for many system builders, now becomes the go-to chip for most budgets, and even mainstream plans.

We'll get to the reason for this glowing preamble shortly, but before we do, it's worth going over what your \$120 gets you. The Core i3-8100 lacks HyperThreading and a Turbo boost, but it does pack four cores into its LGA 1151 package, thrumming along at a perfectly serviceable 3.6GHz. Unlike the Core i3-8350K we looked at a couple of issues ago, this is a simple chip that isn't designed with overclocking in mind, which has an upside in that it operates with a TDP of 65W, so the standard Intel cooler that it ships with handles your needs well enough.

If you're looking to build a budget system around this chip, you're still limited to a single chipset at this point, which starts at around \$115 for a reasonable Z370 motherboard. It's the current cost of memory that is the most frustrating, though, which means that the core

components of CPU, motherboard, and RAM start at around \$300. You do get Intel's UHD 630 integrated graphics in the Core i3-8100, though, which may not be relevant for modern gaming, but it's a solid enough solution for normal desktop use, and—thanks to QuickSync—can handle video encoding while it's at it.

BUDGET BEAUTY

So why all the love for this \$120 budget chip? Because this chip is essentially what sold as a mainstream offering two generations ago—in fact, its performance is as close to the stock performance of the Core i5-6600K as you can get. That's a chip that will still set you back \$240. Of course, that chip that can be overclocked and turbos up to 3.9GHz, but for the most part, there really isn't much to separate the two, apart from halving the price tag on the new processor.

When it comes to the benchmarks, you'll find two comparisons for this chip—the aforementioned \$240 Core i5-6600K and the closest new chip from AMD, the \$125 Ryzen 3 1300X. It's worth noting that the AMD offering doesn't have integrated graphics, which may be a factor if you're not interested in games (this is where AMD's recently released APUs come in, see review opposite). The results from benchmarking are clear, with Intel's budget offering giving AMD's chip a sound



thrashing, with the exception of power draw under load.

If we have reservations, it's that \$120 is still a hefty chunk of cash for those on an extremely tight budget. There is a lot of power on offer here, though, and all those cores should keep this chip relevant for years to come. We do wish that the budget motherboard chipsets would launch, so we can see how low we can get that core component price tag, but that doesn't detract from the fact that this is a great buy right now. It's arguably the most important Coffee Lake chip so far. —ALAN DEXTER

VERDICT
9

Intel Core i3-8100
ECONOMICAL Impressive value; strong performance; functional integrated graphics.
EXCESSIVE Lacks turbo; no overclocking potential; compatible motherboards are pricey.
\$120, www.intel.com

BENCHMARKS

	Intel Core i3-8100	AMD Ryzen 3 1300X	Intel Core i5-6600K
X265 Benchmark (fps)	14.32	12.64	14.37
Cinebench R15 Single (Index)	154	139	166
Cinebench R15 Multi (Index)	601	550	598
Fry Render (Seconds)	388	462	376
AIDA64 Memory Latency (ns)	63	78	59
Total War: Atilla (fps)	40	36	40
Far Cry Primal (fps)	77	73	76
3DMark: Fire Strike (Index)	15,237	14,152	14,981
Power Draw Idle (Watts)	43	56	49
Power Draw Load (Watts)	112	95	114

Best scores are in bold. Our test bed consists of an Asus Maximus X Hero (Intel) or MSI X370 Gaming Pro Carbon (AMD), 16GB (2x 8GB) of Corsair Dominator Platinum DDR4, an Nvidia GeForce GTX 1080, and a Samsung 850 Evo 500GB SSD. All games were tested at 1440p on the highest graphical profile.

SPECIFICATIONS

Base Clock	3.6GHz
Turbo Clock	N/A
Cores/Threads	4/4
Lithography	14nm+
Cache	6MB
Memory Support	64GB DDR4-2400
Memory Channels	2
Max PCIe Lanes	16
Graphics	Intel UHD Graphics 630
Graphics Clock	1.1GHz
TDP	65W

Dell UP3218K

High DPI comes to the desktop

WE LIVE IN A WORLD where tablet computers with high-DPI displays are given away in boxes of breakfast cereal. Well, almost. Such pixel-dense panels are certainly standard on everything from \$99 tablets to low-end smartphones. But cutting-edge desktop PCs? They usually make do with big, fat pixels on their relatively low-res monitors. For a platform that prides itself on early tech adoption, that's disappointing.

It's true that 4K desktop monitors are now relatively affordable. But consider the pixel pitch of your typical 28-inch 4K monitor. It clocks in at just 157 pixels per inch. By comparison, the 326 ppi sported by numerous iPhones over recent years is now seen as substandard. The Samsung Galaxy S8 notches up 568 ppi, and Sony's Xperia Z5 Premium rocks no fewer than 801.

The upshot is that most of us have become accustomed to the crisp precision of high-DPI displays. But not thanks to our PCs. Enter Dell's new 8K monitor. With 7,680x4,320 pixels, it packs four times the resolution of a 4K screen. Factor in the 32-inch diagonal, and you're looking at 275 ppi.

That's isn't quite smartphone territory, but it is well beyond any other display we've reviewed. The result is an intriguing mix of stellar upside and occasional niggles. Running Windows at default 100 percent scaling isn't an option with this kind of pixel density, for instance. Everything is far too tiny. On the other hand, cranking up the scaling comes with its own problems.

Windows itself is a little patchy when it comes to setting the scaling beyond 100 percent for high-DPI displays. Dig into the interface, and you'll find proper scaling support is replaced by the blurring of blown-up bitmaps. But that problem is even more evident on the Internet. Few websites are properly coded for high-DPI displays. That's not always apparent on a small smartphone or tablet screen—it's all too obvious on a large desktop display.

Those caveats aside, there's lots to enjoy. Crispness and precision are on another level. Fonts free from almost all aliasing, for instance, are a particular pleasure. Viewing really high resolution images in all their glory is another obvious upside. That said, graphics pros should note that the UP3218K can only run in full 10-bit per channel color mode at 30Hz; 60Hz requires a drop down to 8 bits per channel.

For motion video, the step up from 8K isn't as subjectively dramatic as that from

1080p to 4K, even if that's a fairly academic observation, given that virtually no 8K content exists. It's also worth noting that smooth native-resolution gaming is largely an impossibility at 8K, even with the most powerful current graphics solutions. In mitigation, interpolated 4K games do look nearly as good as native 4K on a similar sized screen. Elsewhere, the panel itself is a fabulous IPS affair, with fantastic viewing angles, super-smooth gradient rendering, plenty of detail in both white and black scales, and vivid, punchy colors. Generally, it's very nicely calibrated out of the box at default settings, bar a slight warmth to the color temperature.

Final details to note involve some setup and running issues. You need a video card with dual DisplayPort 1.2 connections to enjoy the full 8K experience at 60Hz. Even then, the display has known problems coming out of a Windows-induced sleep. More of a long-term concern are the high temperatures at which the panel runs. It's painfully hot across the top bezel. In truth, the UP3218K feels like an early adopter product, an initial point release, not a refined second-generation device. It's expensive, too. But if you can afford it, and can live with the niggles, those upsides are staggering. —JEREMY LAIRD

VERDICT



Dell UP3218K

■ HIGH DPI Crazy image crispness; high-quality IPS panel; so much image detail.

■ WHY, OH WHY? Very expensive; clunky interface setup; little compatible content.

\$3,899, www.dell.com

SPECIFICATIONS

Panel Size	31.5-inch
Native Resolution	7,680x4,320
Pixel Density	275 ppi
Panel Type	IPS
Maximum Refresh	60Hz
Response	6ms
Contrast	1,300:1
Display Inputs	2x DisplayPort
Connectivity	USB 3.0 hub
VESA Mount	100mm
Warranty	Three years





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Intel 760P SSD 512GB

NVMe performance for mainstream money

LIVING ON the bleeding edge of performance is undoubtedly a blast. But what, in reality, do most of us really want? Good performance, solid reliability, and no obvious holes in the feature set. That's what. Handily, that's exactly what Intel's latest SSD offers. In theory, at least.

As a PCI Express drive in the M.2 form factor, with NVMe control protocol support, it checks all the boxes we like to see from a contemporary SSD. It's also competitively priced for a drive with such a complete feature set. Thus, the Intel 760P SSD represents one of a new generation of what you might call mainstream NVMe drives. It's taken a little while for NVMe to attain that mainstream status, admittedly, but drives such as the 760P, Intel's best value NVMe offering yet, confirm that it's finally happened.

Enabling it all is Intel's latest 64-layer 3D TLC NAND flash memory and a new Silicon Motion controller chipset. Like the 600P before it, the 760P has a customized version of Silicon Motion's firmware. But this time Intel has used Silicon Motion's latest hardware in the SM2262 controller, albeit the mid-range flavor of Silicon Motion's latest NVMe controller family.

As for that flash memory, it's actually the same stuff you'll also find in Intel's 545 SATA drives. That the 760P totally blows the 545 away for claimed performance tells you all you need to know about the limitations of the SATA interface and,

in turn, the antediluvian AHCI control protocol associated with it. PCI Express and NVMe really are a killer combo.

At launch, Intel is offering the 760P in 128GB, 256GB, 512GB, 1TB, and 2TB flavors. In other words, there's a drive to suit most storage needs and budgets. In terms of comparative performance across the range, the 128GB model is conspicuous for offering significantly lower drive performance. But as tested here in 512GB format, you're looking at something approaching the 760P's optimal configuration for performance.

For the record, Intel claims 3230MB/s for sequential read performance, and 1625MB/s for sequential writes; 4K random reads, meanwhile, are rated at 340,000 IOPS, and writes at 275,000 IOPS. In other words, this is a quick

drive. But it's not trying to be the very quickest. However, the 760P is also not a budget NVMe drive. There are a few even cheaper NVMe options that achieve their aggressive pricing by virtue of corner-cutting, such as dropping the PCIe lane count down from four to two, or ditching the DRAM cache memory. But not here. Like we said, this is a full feature drive. But is it actually any good?

In terms of peak performance, we've seen quicker. It's no slouch, with reads of around 3GB/s and writes of 1.6GB/s. But by way of example, Samsung's awesome 960 Pro cranks out 3.4GB/s reads. Similarly, if it's random access performance you crave, the 760P doesn't get anywhere near Intel's own 900P. Of course, the 900P is a far more expensive drive, and leverages Intel's exotic 3D XPoint technology. It's not terribly comparable.

More relevant, you could argue, is the comparison with the likes of Samsung's 960 Evo, a more affordable alternative to the 960 Pro, and one which also uses 3D TLC NAND memory. Our review sample for the 960 Evo was the 250GB model, and thus not a direct competitor for this 512GB 760P model, but the overall picture is of a pair of well matched drives.

It's also worth noting that the 760P has Samsung's previous flagship, the 950 Pro, well beaten. Factor it all in and you have a drive that very much delivers on its remit. Aggressively priced and well specified, the 760P is all about delivering bang for your buck. There are clearly faster drives, but they are also unambiguously more expensive. As a real-world buy, the 760P looks awfully tough to beat. —JEREMY LAIRD

VERDICT
9 **Intel 760P SSD 512GB**
■ **SPEEDY GONZALES** Excellent feature set; great all-around PCIe-powered performance.

■ **DROOPY DOG** Not the fastest NVMe drive on the market; SATA drives still give more storage for less cash.

\$199, www.intel.com

BENCHMARKS

	Intel 760P 512GB	Samsung 960 Evo 250GB
30GB Internal Copy (Seconds)	66	89
Atto Sequential Read (MB/s)	3,048	3,019
Atto Sequential Write (MB/s)	1,619	1,494
CrystalDiskMark Sequential Read (MB/s)	2,811	1,682
CrystalDiskMark Sequential Write (MB/s)	1,593	1,475
CrystalDiskMark 4K Read (MB/s)	75	64
CrystalDiskMark 4K Write (MB/s)	218	191

Best scores are in bold. Our test bench consists of an Intel Core i7-8700K, an Asus Maximus X Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 850 Evo 250GB OS SSD.

SPECIFICATIONS

Capacity	512GB
Interface	PCI Express
Control Protocol	NVMe
Controller	Silicon Motion SM2262
NAND Type	64-layer 3D TLC
Sequential Read/Write (MB/s)	3,230/1,625
Read/Write IOPS	340K/275K
Warranty	Five years

Introducing the Skullcrusher, lord of loudness

This would normally be the point at which we switch it up and start spouting off about the bad stuff, but Sennheiser has denied us that small pleasure. Listening to

So, you should definitely buy this, right? Well, no. Not definitely. The audio mix is going to be polarizing; the fact that we've

Driver Type	Dynamic
Impedance	28 ohms
Frequency Response	10Hz–30KHz
Design Style	Closed back
Microphone Type	Bi-directional ECM
Connectivity	3-pole/2x 2-pole mini jack
Weight	13.9oz
Cord Length	4.9ft (3-pole); 8.2ft (2-pole)



The GSP 600 is not
the most subtle wear.



The essential magazine for all things Xbox

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Seagate IronWolf 12TB

Who's afraid of the big, bad IronWolf?

THESE DAYS, STORAGE is all about solid state. SSDs provide not only by far the fastest performance, they also offer the largest capacities—for a price. Samsung will do you a 30TB 2.5-inch SSD, for instance. Just don't ask how much it costs. You might prefer to spend the money on a new car.

Despite that, there is one application that remains dominated by old-school magnetic hard drives: storage bang for buck. If you want maximum storage density for the minimum possible price, you'll need some spinning magnetic platters.

With that in mind, it's no surprise to find that conventional hard drive technology marches on despite its relegation to a relatively small niche. A little over a year ago, the biggest mainstream hard drives weighed in at 10TB. Now we're reviewing our first 12TB drive, the Seagate IronWolf.

It's closely related to the Seagate Barracuda Pro, but further optimized for NAS applications. In other words, if you've got a NAS box that's set for a drive upgrade, the IronWolf would like to offer its services. Indeed, Seagate offers two versions of the IronWolf: vanilla and Pro. This vanilla drive is aimed at connected homes, SOHO, and SMB apps, while the Pro version is for full-on commercial and enterprise users. Both



are packed with features and technology. That includes Seagate's AgileArray tech, which involves dual-plane balancing, RAID optimization, and advanced power management. Then there's Rotational Vibration (RV) mitigation, including several RV sensors that help maintain performance in multi-drive NAS enclosures that can transmit significant vibrations.

In 12TB trim, the IronWolf sports a total of eight platters, thus 1.5TB per platter. As a consequence, its 3.5-inch chassis is crammed. The usual recesses on the bottom of the drive are nowhere to be seen. Rounding the main feature set out is the 7,200rpm spindle speed and a chunky 256MB of cache, all running through a standard SATA 6Gb/s interface. Overall, this 12TB model is rated at 180TB per year of data traffic, has an MTBF (mean time between failures) of 1 million hours, and a three-year limited warranty.

For context, the IronWolf Pro is optimized for 300TB per year, has an MTBF of 1.2 million hours, and a five-year

warranty. In reality, there's probably little in it in terms of the hardware. The Pro is mainly buying more peace of mind in terms of the longer warranty. Whatever, what we're looking at is pretty much the state of the art when it comes to mainstream conventional hard drives, and one hell of a lot of storage for a pretty reasonable price.

Granted, a 3TB or 4TB drive may offer marginally more storage per dollar, but the 12TB IronWolf is pretty competitive in that regard, and offers unbeatable data density. You could, for instance, swap out all the 3TB drives from a quad-drive NAS enclosure for just one of these puppies, and then add further drives when budget or requirements dictated.

Anyway, the 12TB IronWolf looks good on paper and offers a pleasing capacity-to-dollar ratio. But how does it perform? By the standards of a conventional magnetic drive, it's seriously swift. You're looking at sequential reads and writes in the 260–270MB/s region. The 4K random access performance is where magnetic tech really shows its age, compared to solid-state storage. 4K reads of around 1MB/s and writes just under 3MB/s would be utterly catastrophic for an SSD; for this type of drive, they're very much competitive.

The bottom line is that you're not going to get anywhere like the performance of even a budget SSD. But that was a given. If you want major storage density at a reasonable price, however, the IronWolf achieves that, and throws in excellent performance for this type of drive. —JEREMY LAIRD

VERDICT
9

Seagate IronWolf 12TB
■ GOLDILOCKS Epic storage capacity; awesome feature set; great in-class performance.
■ BIG, BAD WOLF Not the best for TB/\$; blown away by any SSD for performance.
 \$429 www.seagate.com

BENCHMARKS

	Seagate IronWolf 12TB	HGST Ultrastar He10 10TB
30GB Internal Copy (Seconds)	267	264
Atto Sequential Read (MB/s)	271	251
Atto Sequential Write (MB/s)	267	253
CrystalDiskMark Sequential Read (MB/s)	266	246
CrystalDiskMark Sequential Write (MB/s)	263	248
CrystalDiskMark 4K Read (MB/s)	1.16	0.71
CrystalDiskMark 4K Write (MB/s)	2.95	5.97

Best scores are in bold. Our test bench consists of an Intel Core i7-8700K, an Asus Maximus X Hero, an Nvidia GeForce GTX 1080, 16GB of Corsair Dominator Platinum DDR4, and a Samsung 850 Evo 250GB OS SSD.

SPECIFICATIONS

Capacity	12TB
Interface	SATA 6Gb/s
Spindle Speed	7,200rpm
Max Sustained Transfer Rate	210MB/s
Cache Memory	256MB
Control Protocol	AHCI
Platters	8x 1.5TB
Number of Bays	1-8
MTBF	1 million hours
Warranty	Three years

Corsair Hydro H150i Pro RGB 360mm

The sound of silence

WHEN IT COMES to thermal dissipation, nothing truly compares to a good liquid-cooled setup. Say what you like, but for clean builds, ridiculous efficiency, and noise reduction, AIOs are the way forward. Those early teething days are now long gone, and with most AIOs packing an impressive five-year warranty to boot, you can rest assured that if your cooler decides to self-destruct and spray its conductive juices all across your precious hardware, the manufacturer will go out of its way to ensure you get either hard replacements or cash up front as soon as possible. That's



more than enough for us to recommend them. Admittedly, if you do need absolutely concrete cooling, with zero downtime, the more premium air towers still fill that niche far better—but for the average enthusiast, consumer, or tinkerer, the AIO is the perfect partner for any thermal predicament.

That said, maximum core counts have almost doubled in the last year alone, so the need for more powerful cooling solutions has grown, and although this isn't the first time we've seen a triple-rad AIO (Swiftech was first to market), it's the first we've seen from Corsair, and one that isn't

based around Asetek's rather aggressive patenting at that.

Aesthetically, the Hydro H150i Pro RGB is a whole different beast from the now-legendary "old-school" H100i we used to know and love. The design, bezel, fans, lighting have all been redeveloped from the ground up around Corsair's (and the whole industry's) new obsession with RGB. Not that it's entirely a bad thing. The Hydro's appeal lies within the small details Corsair has integrated into the unit. Whether it's the aluminum-flecked logo embedded into the side of the rad, the braiding covering the tubing between the block and the radiator, or the RGB-lit block itself, it all combines to make an exceptionally clean-looking piece of hardware. Almost.

It's that octagonal block that is arguably the most divisive part of this mixture, with the stark silver of the thick bezel standing out perhaps a bit too much for our liking. If it were a simple black brushed finish instead, or even absent, it's not something we'd particularly miss. But let's face it, designing a cooler that doesn't encroach on the competition's style, yet is still decisively a Corsair product, is a challenge, and there are limited things you can do with a waterblock. NZXT has the Kraken's mirrored finish, Cooler Master has the subtle sand-blasted styling, and Thermaltake has, well, all the RGB and cables—cables for days—so we understand that those designer decisions are pretty slim pickings right now.

The real beauty of the Hydro H150i Pro RGB, however, lies in the cooling—or rather, the very obvious lack of noise associated with said cooling. It's the fans. Corsair has upgraded the stock fans usually included with AIOs, using a set of three ML120 maglev variants (some of our favorites) instead. Combine that with the addition of a zero-RPM fan mode in the Corsair Link software suite, and fan noise can be

reduced to an absolute minimum with ease, with the fans only kicking in when the CPU reaches a temperature of your choosing.

Corsair's Hydro H150i Pro RGB is a fantastic addition to this mammoth company's arsenal. It's just that the CPU block is going to be so divisive, especially among people who prefer the sleeker, more professional designs associated with Corsair's Graphite series of cases and more. What we'd love to see in the future is a way of replacing that bezel with potentially different colored frames, or perhaps a sleeker block entirely, integrating Corsair's love and talent for RGB, while retaining the Graphite's serious sensibility. All that said, if you've got the space for it, and are after the quietest AIO on the market, the Hydro H150i Pro RGB is the perfect fit for any silence-loving, cool-craving PC tinkerer. —ZAK STOREY

VERDICT
9

**Corsair Hydro H150i Pro
RGB 360mm**

■ **ODD FAN TECH** Awesome fan curves; solid fans; good performance; intuitive mounting mechanism.

■ **JUST BROKEN** Divisive CPU block; pricey.

\$170, www.corsair.com

SPECIFICATIONS

Socket Compatibility	AM2, AM3, AM4, FM1, FM2, LGA 115X, LGA 2011-3, LGA 2066
Radiator Size	360mm
Radiator Dimensions	15.6 x 4.7 x 1.1 inches
Cold Plate Material	Copper
Fan Static Pressure	1.78mmH ₂ O
Fan Airflow	47.3CFM
Fan Noise	25dB(A)
Warranty	Five years

BENCHMARKS

	Corsair Hydro H150i Pro RGB 360mm + Stock Fans	NZXT Kraken X62 + 2x Noctua AF14 Fans
Idle Temperature (°C)	23	25
Prime95 @ Stock (°C)	52	55
Cinebench @ Stock (°C)	48	48
Far Cry Primal @ Stock (°C)	43	44
Prime95 @ 4.7GHz (°C)	79	75
Cinebench @ 4.7GHz (°C)	73	62
Far Cry Primal @ 4.7GHz (°C)	56	51

Best scores are in bold. Our test bed consists of an Intel Core i7-6700K, a GTX 1080, 16GB of Crucial Ballistix Elite, and a 500GB Samsung 850 Evo SSD. All tests were performed for five minutes each, with a 10-minute cool-down period.

Even at full
whack, this
thing is quiet.

The twin moons make it clear
we're not in Kansas anymore.



Outcast: Second Contact

Dimensional rift opens to world of right angles

SEQUELS AND REMAKES are the backbone of the modern game industry, the boughs from which the fruits of original creative endeavors can hang. And they have another important function—making great games from the past accessible to those who don't have Windows 98 installed, or even a CD drive in their PC anymore.

Seventeen or so years ago, *Outcast* was cutting-edge. You needed 128MB of RAM to run it, and a beefy CPU (Pentium IIIs were available), thanks to its eschewal of GPU tech (the first GeForce card would come along in October 1999) to run an engine that flitted between raycasting for the ground and textured polygons for objects.

An enhanced version, *Outcast 1.1*, was released in 2014, but it stuck with the CPU rendering of the original, and was on the blurry side, which is an accusation you can't make of *Second Contact*. It looks superb, every texture beautifully displayed, every face animating in time to its spoken lines, and the swirling snowflakes of the opening sequence looking soft and featherlike. However, from this fidelity comes the sense that you're playing an old game—everything is very square, the ground very flat, even where it's built up in layers. Mountains jut

suddenly out of the surface, nestling plants and crystals at their base, as though trying to hide the joins. It's all very 1999.

Not that it should matter, as there's a solid game beneath the shiny new polygons. *Outcast* is a third-person free-roaming adventure game, although the amount of free roaming you can actually do is curtailed by monsters, enemies, and quicksand. Humanity has wrenched open a portal to another dimension, and sent through a probe, but it's all gone wrong, and a dimensional vortex now threatens to destroy our world if you, Commander Manly (sorry, Cutter Slade), don't go through the breach and reclaim Earth's litter. Of course, you get separated from your team, and wake up in a square house, surrounded by beings whose baldness and two-fingered hands must cut down on rendering time nicely. They speak perfect English.

It's full of charmingly clunky touches, such as the Gaamsaav device you carry in your backpack and use to saav your gaam. We're not sure if the fact the Gaamsaav makes a noise that enemies can hear and will investigate is a stroke of genius or sadism, but it's certainly effective at racking up the tension. Your character looks like an

idiot with his gun drawn, as if he's holding it in the very tips of his fingers, which possibly explains why the auto-aim is a bit wobbly, and his reluctance to turn around means running backward is an effective method of withdrawal from suboptimal situations. Modern touches include autosaving, and switching rechargeable health on or off.

Outcast's John Carter meets Jack O'Neill nature is spread thinly over its structure, the workings of the world are on display, and as you mess with them—disrupting enemy supply lines, for example—you can see its influence on games such as *Assassin's Creed*. *Second Contact* is interesting as a historical document, sure, but it's still a great game in its own right. Especially now anyone can play it. —IAN EVENDEN

VERDICT



Outcast: Second Contact

■ **OUTCAST** Huge adventure; top-notch remake; fine score.

■ **OUTHOUSE** Clunky '90s plot and lead character; showing its age elsewhere, too.

■ **RECOMMENDED SPECS** Intel i7/AMD Ryzen 5; 8GB RAM; GeForce GTX 780/AMD Radeon 290.

\$35, <http://outcastthegame.com>, ESRB: T



Spellforce 3

A genre-blending hybrid that puts the RTS in RPG

SPELLFORCE'S CLASH of initialisms flings RTS together with RPG, and contains the resulting fusion in a series of narrative arcs within a generic fantasy world. As a result, what looks like a standard isometric RPG in the *Baldur's Gate* mold sees you building bases, raising an army, and taking the fight to the bad guys as a mass of troops, rather than a small party of heroes. Although there is a small party of heroes, too, who have all the special powers and upgradable skill trees you could want.

The RTS interludes help avoid the RPG sections feeling hackneyed. There are dwarfs, orcs, and elves, magic users both good and bad, a religion that persecutes those magic users, a dungeon escape, whirling rumors of a chosen one, a long-dead civilization you can raid for awesome loot.... If you've played *Tides of Numenera* or *Divinity: Original Sin*, you might wonder how far back in time you've traveled.

Spellforce gets away with it, though. Your companions are amiable enough, even if the dwarf is Scottish, and change at swift enough intervals to not get boring. They've always got something to say, and there's a rich vein of sarcasm to be mined in your responses, such as suggesting to

one character he might like to pop out of the dungeon for art supplies when he mentions sketching the ancient ruins you found. It can raise a smile, even as you raise your sword to beat down more goblins.

There are issues. The text contains a great many typos, which is just about bearable, as every line is voiced, and probably irks us as magazine journalists more than others. Another issue is that areas highlighted as being of interest repeatedly fail to be interesting—your character walks up to them, says something like, "What do we have here?" then does nothing. At one point, some helpful text advised us to use an item we hadn't obtained yet. We even had a loot drop that was impossible to pick up, and a cutscene that didn't want to end, leaving us waiting without control until, as if from nowhere, normality re-established itself.

This kind of thing is rare nowadays, and the developers continue to patch and improve the game post-release. We didn't encounter anything game-breaking, even if we did miss out on some loot—but there's plenty of that. Our characters were weighed down with weapons and armor they couldn't use, with books and scrolls, meat from slaughtered enemies and animals, potions

to restore us and protect us from magic. Their backpacks must be enormous, but this constant turnover of weapons and the huge number of "uncommon" healing potions are another step toward accessibility and the game's continued holding of your attention.

In the tussle at the heart of *Spellforce 3*, the forces of RPG have the upper hand over scrappy RTS soldiers. But the RTS sections make the game feel fresh, adding interest to a world that might otherwise be dismissed as just more elves. It's a balance that's been struck deliberately, and the mix works well. There's hours of play, and the fast pace means it's unlikely to get boring soon. If this is how genres can be hybridized, we say, "More crossbreeding!" —IAN EVENEDEN

VERDICT
8

Spellforce 3
SPELLS Hybrid structure holds interest; good script; epic story.
SMELLS Buggy and typo-ridden; can feel like every other RPG you've played.
RECOMMENDED SPECS Intel Core i7-4790/AMD FX-8350; 8GB RAM; Nvidia GTX 970 4GB/AMD Radeon R9 290 4GB.
 \$50, <http://spellforce.com>, ESRB: M

LAB NOTES

ALAN DEXTER, EXECUTIVE EDITOR



Memory is Holding Us Back

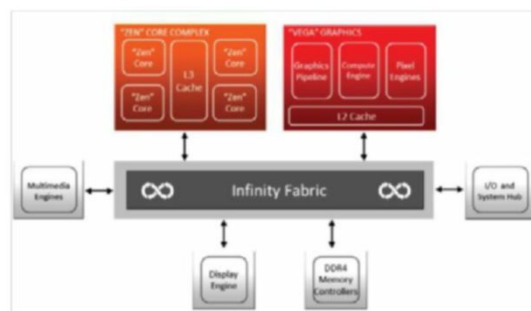
Infinity Fabric is awesome, if you have lots of cheap, fast RAM

IF YOU'VE READ our review of AMD's new Ryzen 5 2400G (pg. 78), you'll know that we think it's a quality budget chip. In fact, we're stoked about the kinds of machines we can build around it, and what kind of price points we can hit with it as a base. The fact that it boasts integrated graphics that don't completely suck, at a time when graphics card prices have lost all grasp of reality (a comparable GeForce GT 1030 will set you back \$100) makes for a compelling story on its own.

The problem is, and it's a problem that affects pretty much any build at the moment, is memory pricing. Basic RAM is too expensive, and the speedy stuff even more so. This affects AMD's Raven Ridge APU's more than anything else currently out there, because the Infinity Fabric that forms the heart of the chip's

communications—forming the link between the APU's six main components—runs at the speed of your memory. Faster memory equates to better CPU performance, better GPU performance, and just better performance across the board. You need quality, fast memory. Yeah, the expensive stuff. To go alongside a budget powerhouse.

What sort of performance difference are we talking? Well, in games you're looking at dropping from 30fps with DDR4-2933 down to 24fps with DDR4-2400, or from 60fps down to 50fps. Enough of a difference to force you to turn off even more settings, drop the resolution, or simply



You'll want the fastest memory you can afford.

make a game unplayable. We'll look at this in more detail next issue, along with a look at the Ryzen 3 2200G, but for now, realize that memory performance is not only important again, but it can make a real difference to the viability of a platform.



TUAN NGUYEN

Editor-in-chief

I think everything has pros and cons. One of the cons of being knowledgeable in tech is you will inevitably become someone's go-to tech support person. Whether that be your parents, friends, or other relatives, it'll just happen. The worst part of this arrangement is that if something goes wrong again after you've fixed the issue, they'll blame you. And

once again, you'll be called on to fix it. Don't get me wrong, I like solving problems. I do genuinely enjoy helping people solve their problems. It's just that sometimes, problems keep happening to the same person that you keep helping. Not because they're actual problems, but because now they've got loads of questions. I should start charging.



BO MOORE

Technology editor

I helped a friend build her first PC during Black Friday last year—at least, that's when we bought all the components. I was reporting on hardware component sales, and I simply sent her the best deal in every category that I could find. We ended up assembling a mighty fine computer for less than a grand, but we made one fatal error. She was a bit bullish

about which GPU to buy, and I wasn't seeing any deep discounts anywhere on the GTX 1070 we had priced out, so I told her to just hold off and wait for a better sale. Oh, what a mistake that was. Months later, the GPU shortage continues, and we haven't seen prices anywhere close to the near-MSRP price I scouted that day.

Editors' Picks: Digital Discoveries

Jarred Walton, senior editor, and Zak Storey, deputy editor, share their recent technology loves



DATAVAC ED-500 ELECTRIC DUSTER

If you haven't cleaned out your PC's internals lately—in the past six months at least—stop reading. It's time for some spring cleaning, so grab your screwdriver, crack open your case, and take it outside for a good internal dusting—and don't forget your keyboard. But wait, are you using canned air? Not only can that stuff be bad for the environment, but it's completely unnecessary. There are far better alternatives.

I've used a small Shop-Vac in the past, but it's big, noisy, lacks small nozzle attachments, and isn't nearly as convenient as the DataVac ED-500. Don't let the diminutive size fool you, as it really blows—it has a 500W motor for just that purpose. Whether it's blasting dust from your case or removing crumbs and other tasty morsels out of your keyboard, it has six attachments, from the tiny air-pin pointer to the larger air-flare nozzle, to get the job done.

The retail price is a bit steep, but you can pick this up from Amazon for around \$70. That's about the same price as a dozen or so cans of compressed air, but without the extra landfill and chemicals. It's especially good in offices where there are lots of computers to clean.

\$118, www.metrovacworld.com

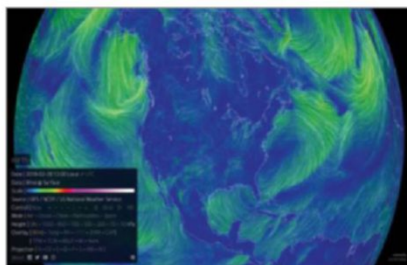


EARTHWINDMAP

I have a thing for weather—no, seriously. I come from a family of builders and farm laborers on my father's side, and some of my most cherished childhood memories are of waking up every morning at 6 a.m., sitting downstairs with my pops, and watching the weather forecast, trying to figure out whether he'd be going to work that day or not. During my teenage years, I'd often spend my summers working as a laborer for all manner of construction professions, and post varsity, it was that same work that tided me over until I found my first "proper" job here at *Maximum PC*.

So, weather's really important for me. And when meteorology and technology come together, I get perhaps a little over excited. Whether it's live lightning strike maps, or fancy smartphone apps, it's all awesome. The EarthWindMap site is by far the best thing I've found lately. It's a live and interactive weather map, powered by a ton of organizations, depicting all sorts of neat visual representations of our planet's habits, from wind speed to temperatures, pollution, wave size, and even a "Misery Index," which tells you just how miserable the weather is on a neat little scale. You can even look into the future, and best of all, it's free.

Free, <http://earth.nullschool.net>



Corsair Gaming PBT Double-Shot Keycaps

I REMEMBER THE EMAIL: "Zak, you can review keycaps, right?" Apprehensively, I said yes, but I've held on to them for a long while before even testing them, much to Corsair's disdain.

So what's the point of these, and why should you invest 50 bucks in them? That's a lot of beer (64.93 bottles—I did the math*). If you've already invested in a mechanical keyboard, the likelihood is you've put a good \$120 into it, so why drop more cash? Well, most keycaps are molded out of a single piece of plastic, and the character is laser-etched into it. The Double-Shots, on the other hand, are formed from two separately molded pieces of plastic: one translucent to allow your RGB light of choice to pass through, and another more solid outer coating to go on top. That means heavier caps, and a more durable finish. Theoretically, these shouldn't wear out as easily.

While I can't comment on durability, what I can say is that both variants look stunning. The lighting, in particular, is far superior to the original caps on my K70, and the feel is as comfortable as a keycap can be. The font is still a bit garish to me (personal preference), but that aside, they're solid. Is it worth the 50 dollars, though? Well, it depends how trashed your current caps are. I'd love to see these make it into Corsair's next-gen keyboards as standard, that would certainly make a lot more sense. **—ZS**
\$50, www.corsair.com

* Beer calculation based on an 18-pack of Miller Lite, price correct at time of writing. Maximum PC reminds you to always drink responsibly.

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

- > Color Confusion
- > Exhausting Issues
- > System Specifics

Living Color

I've kept all of my *Maximum PC* magazines since you started publication. When I received my March 2018 edition, however, I noticed something peculiar. Because I stack all my magazines with the spine facing outward, I saw that the March 2018 issue had the same color scheme as the February 2018 one, with just the subtle change of the front cover. Is this the Illuminati confirmed, or did the color picker person lose their creativity?

—Kolby Aggramar

ART EDITOR (AND CHIEF COLOR PICKER) FRASER MCDERMOTT RESPONDS:

Just like everyone else in the office, I have my issues lined up with their spines showing as well—it's a timeless system that's been used for storing magazines and books since... well, forever. A keen eye would have spotted that the spine on the February issue was a mix of 85 percent cyan, 5 percent yellow, and 5 percent magenta, though, while clearly the March issue is just 75 percent cyan. Quite a difference, I

think you'll agree. The spine color is designed to use the main accent from the cover, so while the cover images for the issues in question are very different, they use a similar accent, thus the similar (though really very different) spines.

Screen Scene

Approximately two years ago, in a monitor comparison, *Maximum PC* gave very positive reviews of the BenQ GW2765HT 27-inch 1440p IPS monitor. This monitor has dropped in price now. I understand that it has been some time, and technology has progressed, but for gaming and general desktop use, does this monitor still make the cut, or is there a better choice? Possibly another monitor comparison would be good.

—Jimmy Croskey

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: When we looked at the BenQ GW2765HT screen back in the February 2016 issue, it walked away with the Kick Ass award and won the screen roundup it appeared in. At the time, it had a list price of \$350, which was

half the price of the other stand-out screen in that test, the impressive Asus ROG Swift PG279Q. We've just had a quick look around, and the BenQ can now be had for about \$300, which is a nice sweetener for an already great value panel. There have been a lot of developments in the screen market, but they tend to have focused on 4K displays, so while it is now getting a little long in the tooth, it's still a great buy. You can pick up a 4K screen for only a little more, but we still see 1440p as the sweet spot for gaming, so this still gets our nod.

Being There

I've been a *Maximum PC* subscriber for many years, and always find something interesting and useful in every issue. I'm hoping you can help me with a question. I would like to find a "player" for Android and/or Windows 10 that will respond to the movements of the tablet to get the VR effect. I'm using a Gear 360 camera to create the video, but haven't been able to find anything that will give me the playback experience I'm looking

for. Any suggestions you can offer would be greatly appreciated.

—Wes Bell

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: What you're asking for seems completely reasonable, especially as you'll find the likes of Facebook and YouTube peddling the sort of experiences you're trying to recreate, but it would appear that it isn't as straightforward as you'd expect. In fact, looking around, we couldn't really find anything that quite hits your brief.

The one thing we did find was the GoPro VR Player, which you can get for free from www.kolor.com/gopro-vr-player. Although it does enable you to play back your 360 videos and look around them, I'm not sure it does exactly what you want. Hopefully another reader can suggest something a little more immersive.

Hole in One

Why do most all computer cases come with back fan exhausts with these ugly perforated holes that block over 70 percent of airflow from the fan, and make all

submit your questions to: comments@maximumpc.com



the noise? A simple hole will do much better. I cut holes for fans in all my cases so fans can work. Same for PSU bottom mounts that have screens. —Don Hoffman

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: It's a blatant exaggeration to say that grills can restrict more than 70 percent of the airflow (we'd suggest less than 10 percent for most designs), but you have a point when it comes to adding to fan noise and stopping them working optimally. We've just had a quick look around the office, and there are a lot of "normal" machines that have designs that do indeed appear to hinder airflow, rather than promote it.

Your solution of cutting holes where your fans go has some merit, especially from the perspective of keeping your noise levels down and improving airflow. There is one obvious problem with drilling/cutting out all of your grills to improve airflow in that little fingers now have nothing to stop them prodding into our beloved machines (causing damage either to said fingers, or the fan blades). If you are going to remove all the grills, but do have little ones to bear in mind, wire grills can help protect your system and have the least effect on both fan noise and performance.

More of a Difference

Just found this magazine a year ago, and I love it so much. I end up building PCs on a semi-regular basis, since my parents are engineers and my brother and I are college students, and I'm the only PC enthusiast in the house. Anyway, my default source for product reviews when spec'ing a new system is your magazine, because unlike reading online customer reviews, I can expect a lot more content than just jokes about graphic

[NOW ONLINE]

HACKERS INFILTRATED TESLA'S AMAZON CLOUD ACCOUNT TO MINE CRYPTOCURRENCY

Tesla is the latest victim of what's known as cryptojacking, which is when a company is hacked and its resources used to mine cryptocurrency. In this case, hackers were able to break into Tesla's Amazon cloud account.



Cybersecurity startup RedLock Cloud Security Intelligence (yes, that would be CSI) discovered the intrusion last month. Or, more accurately, it stumbled upon the intrusion while investigating Kubernetes administration consoles being accessible over the Internet due to a lack of password protection. These consoles are designed to help IT admins manage virtual machines.

"A couple of the instances belonged to Aviva, a British multinational insurance company, and Gemalto, the world's largest manufacturer of SIM cards. Within these consoles, access credentials to these organizations' Amazon Web Services (AWS) and Microsoft Azure environments were exposed. Upon further investigation, the team determined that hackers had secretly infiltrated these organizations' public cloud environments and were using the compute instances to mine cryptocurrencies," RedLock said.

Read the full article at <http://bit.ly/2EJ2PPP>

cards running *Minesweeper* at one billion FPS.

What I want to ask is: Would it be possible to get a greater quantity and diversity of reviews? I love that the magazine already has an awesome diversity of budgets considered—if a Pentium or i3 is the cream of the crop, you aren't afraid to say so. But I'd like to see a bit more diversity—gamer components suit most of my purposes just fine, but I'd love to see reviews of things like NASes, Nvidia Quadros, the Titan V, pre-built HP and Dell workstations, tablets, high-quality soundcards, and musician-quality (not "gamer") headphones. Just being nit-picky, though. This magazine is awesome!

—Kieran Al

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: It's good to hear you are enjoying

the magazine, and that we've become a trusty companion to your builds. As for expanding our remit, we've actually covered some of these items already (in fact, you'll find a review of the Titan V this issue, on page 76), although others we steer clear of simply because a generalized review isn't particularly useful. How one person uses a professional graphics card is often completely different to how another does, and a more general review wouldn't necessarily be useful to our readers.

Be Specific

I read the article about setting up the Raspberry Pi with Kismet in the March 2018 issue of *Maximum PC*. In the beginning of the article, you talk about the need for a monitor mode enabled Wi-Fi adapter, but

it says "TP-Link TL-WN72N" in the text—I guess you are referring to the TP-Link TL-WN727N adapter that is pictured in Image B within the article.

One more thing that is crucial to know is what version of the TL-WN727N adapter you were using. The risk is that readers want to follow your example setup (since it is the easiest way to get started) and just buy a TL-WN727N. However, the chipset is not the same in many models of Wi-Fi adapters, even though the model name remains the same over versions. The TL-WN727N, for example, has at least three different chipsets, depending on the version at hand. The v1 has a Ralink RT3070 chipset, v3 has a Ralink RT5370 chipset, and the v4 has the MediaTek MT7601U chipset (some v4s have the Realtek RTL8188EUS chipset). I'm not all sure that all those chipsets a) work out of the box with Raspbian Lite or b) can offer monitor mode. It could be good to know so that readers don't rush and buy adapters that they think should work, but won't.

I am very aware of the fact that you are just suggesting examples of equipment to get started, but for this kind of "war driving" scenario, it would also be good to use a Wi-Fi adapter that has an external antenna, for range reasons.

—Jonas

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We've seen wildly different hardware branded with the same name before, so while we're not surprised that there are so many versions of the TL-WN727N, it's still annoying. You actually want to make sure that you get the original v1 spin of the TL-WN727N, which uses the Ralink RT3070 chipset. The main point remains, though, that you've got to make sure it supports monitor mode when buying it, whichever dongle you get. 🔄

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INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Evolv ITX	\$70
PSU	EVGA 450 BT Bronze	\$45
Mobo	ASRock AB350 Gaming-ITX/ac	\$95
CPU	AMD Ryzen 5 2400G NEW	\$169
GPU	N/A	\$0
RAM	8GB (2x 4GB) G.Skill Ripjaws V Series 3200 NEW	\$104
SSD	120GB HP M700 2.5-inch SSD	\$50
HDD	1TB WD Blue 1TB 5,400rpm	\$46
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	\$16

Approximate Price: \$595

YEAH, SCREW YOU, GRAPHICS CARDS, we don't need you anymore, you're crappy. Well, not really, but honestly, we're really fed up with having to deal with the perpetual price increases. Seriously, 2017 saw three million GPUs bought up by those pesky cryptocurrency miners, and as much as we like to get behind new and intuitive ways of making money with technology, GPU scalping simply seems too far below the belt for us to vouch for. All hail our new AMD overlords, then, and in particular the Ryzen 5 2400G. Those Vega cores beating away at the heart of this APU are plenty powerful enough to enjoy a mid-range gaming experience at 1080p. And it's for that exact reason that we've chosen the 2400G as our budget chip of choice. Flexing that card cash has also given us the opportunity to drop some higher specced memory in here, too, ensuring you get the most out of our APU bro and its Infinity Fabric.

INGREDIENTS

PART		PRICE
Case	NZXT S340 Elite	\$90
PSU	550W Corsair RM550X	\$100
Mobo	MSI Z370 Tomahawk	\$150
CPU	Intel Core i5-8400	\$182
Cooler	Be Quiet! Dark Rock 3	\$75
GPU	Asus GeForce GTX 1060 3GB Dual NEW	\$340
RAM	16GB (2x 8GB) ADATA XPG Gammix D10 2400 NEW	\$169
SSD	256GB Intel 760p Series M.2 PCIe SSD NEW	\$99
HDD	Western Digital Blue Series 1TB 7,200rpm	\$49
OS	Windows 10 Home 64-bit OEM	\$100

Approximate Price: \$1,354

SAVINGS HATH COMETH to the people, and boy does it feel good to say that. Unfortunately, this is due to a few smart saving tactics we've employed since last issue—but, fortunately, now you can get a semi-decent GPU for less than \$600. We've swapped out the 6GB GTX 1060 in favor of Asus's 3GB variant instead, saving a not-so-subtle \$260, and we've also opted to go for both a lower specced kit of memory (because this is an Intel build) and a more read-oriented PCIe SSD, in the form of Intel's 760p series, the latter of which saves us \$46 over last issue's SM961. There's one other saving here, although it's not one we can report on in our table above: Our choices of motherboard and CPU can be bought together in a bundle, potentially saving you an additional \$35 on top of what we've listed. Generally, if you can find combos like that, we recommend you snap them up. Just make sure the CPU comes with a cooler.



IT'S FINALLY HAPPENING: Prices are coming down, and it's such a beautiful thing to behold. GPU prices are finally tumbling—well, for now at least. You can get a GTX 1080 for \$630 now, and a 1080 Ti for \$300 less than it cost last issue. That's something we can absolutely get behind. Memory prices are still pretty frantic, but hopefully as companies in China have begun to produce DRAM at a fairly steady rate, we should see those prices drop as well, meaning happy days once more for us consumers. Let's hope the prices continue to fall for the foreseeable future. Speaking of which, we're going to point out another bundle. You can currently pick up the motherboard and CPU listed here for a little over \$1,003 bundled—compared to \$1,100 if bought separately—dropping the overall price of this rig down closer to \$3,150, which is almost stomachable.

So, now the panic and furore are out the way, let's talk specs. We've gone for a smaller cooler for our 1920X, to ensure there's no compatibility issues with the case. We did manage to make last issue's cooler fit, although it was snug, for sure, and less than ideal. But apart from that, we've kept most of this build the same, bar the GPU, opting for MSI's triple-cooled black (and very stylish) DUKE. It's arguably one of the nicest out there right now, if only because the thing isn't littered with RGB. Storage remains the same, and we've stuck with the same 32GB kit of 3,200MT/s memory as well, because it's still the perfect match for that 12-core Threadripper.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART		PRICE
Case	Phanteks Eclipse P400S Tempered Glass Silent Edition	\$90
PSU	Corsair RM750X Modular Gold	\$110
Mobo	Asus Prime X399-A	\$350
CPU	AMD Ryzen Threadripper 1920X	\$750
Cooler	Noctua NH-U12S TR4-SP3 120mm NEW	\$70
GPU	MSI GeForce GTX 1080 Ti DUKE 11G OC NEW	\$900
RAM	32GB (4x 8GB) G.Skill Ripjaws V Series DDR4 3200	\$364
SSD	512GB Samsung 960 Pro M.2 NVMe	\$330
HDD	4TB WD Black 7,200rpm	\$186
OS	Windows 10 Home 64-bit OEM	\$100

Approximate Price:

\$3,250

UPGRADE OF THE MONTH



AMD RYZEN 5 2400G

There's just something admirable about the fact that you can now get a processor with integrated graphics that's powerful enough to run *Overwatch* at 1080p and get 60fps without much of a struggle. It's simply so satisfying. AMD's Ryzen 5 2400G is an incredibly versatile chip, and one that overclocks like a tank, too, if you put some decent cooling behind it. We've heard rumors of it hitting 4.4GHz in some samples, and showing off single-core performance well above anything we've seen from the architecture to date, even trumping the Ryzen 7 1800X. All in all, it's a very tantalizing offer for anyone looking to build a budget rig, and if it's any indicator as to how Zen+ is going to perform come April, it's going to be a fun time to be a tech enthusiast, that's for sure.

\$169, www.amd.com

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